



# Cleaner Indoor Air During Wildfires Challenge

## Announcement of Phase 1 Winners - October 26, 2021



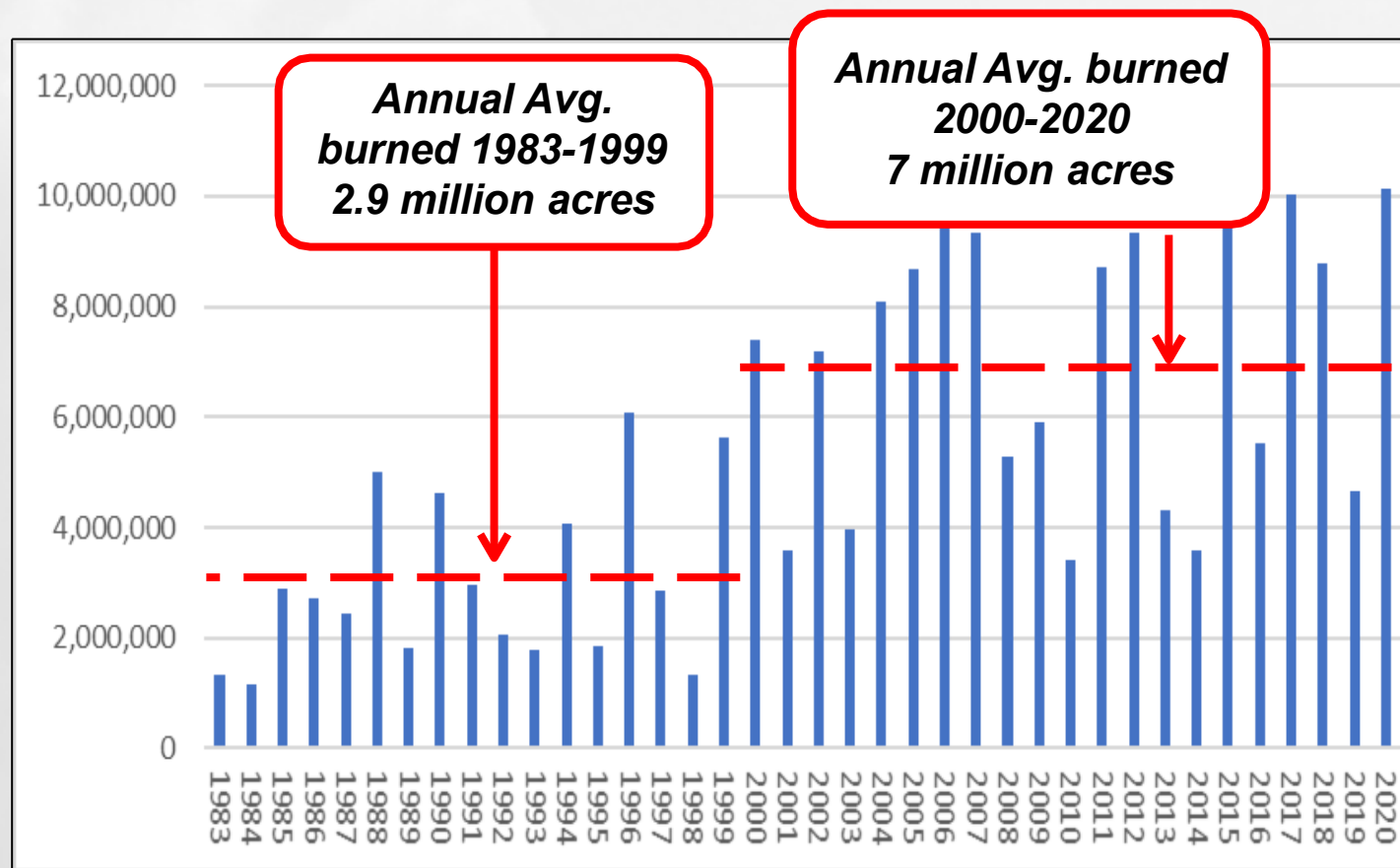
Red Salmon Complex Fire (CA) 2020

Photo Credit: Tristean Kiehl

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# Wildland Fires are a Growing Issue

- Magnitude and frequency of wildland fires are worsening
- Many U.S. communities are exposed to wildland fire smoke for days, weeks, or even months
- Biden-Harris administration is working across organizations to address wildfires



Adapted from [https://www.nifc.gov/fireInfo/fireInfo\\_stats\\_totalFires.html](https://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html)

BRIEFING ROOM

## FACT SHEET: The Biden-Harris Administration Acts to Address the Growing Wildfire Threat

JUNE 30, 2021 • STATEMENTS AND RELEASES

<https://www.whitehouse.gov/briefing-room/statements-releases/2021/06/30/fact-sheet-the-biden-harris-administration-acts-to-address-the-growing-wildfire-threat/>

Learn more about EPA Wildland Fire Research to Protect Public Health and the Environment at:

<https://www.epa.gov/air-research/wildland-fire-research-protect-health-and-environment>

# Focus of Today's Webinar: Indoor Air Quality during Wildfires



Photo Credit: Winnacker

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Highlights of recent EPA  
collaborations

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Brief introduction to the  
Wildfire ASPIRE Study

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*Cleaner Indoor Air During Wildfires  
Challenge: Phase 1 Winners*



# ASHRAE Guide for Building Managers

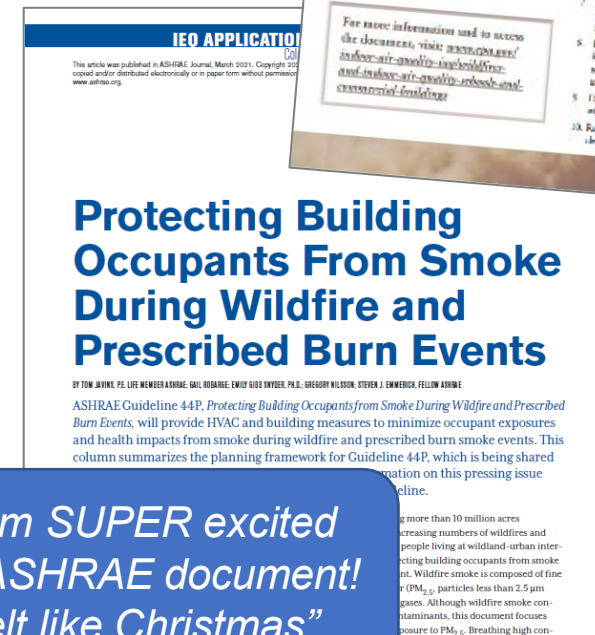
- ASHRAE committee released interim planning framework in Feb 2021

- [Protecting Commercial Building Occupants from Smoke During Wildfire Events](#)

- Focuses on preparing for wildfire smoke, including heating, ventilation, and air conditioning (HVAC) readiness
- Final guideline expected to be completed in 2022

Learn more at:

[Wildfires and Indoor Air Quality in Schools and Commercial Buildings](#)



*“And I’m SUPER excited for the ASHRAE document! ...it felt like Christmas”*

**Sarah Coefield** (Missoula Partner)

# DIY Air Cleaner Safety

- EPA partnered with Underwriters Laboratories Research Division (Chemical Insights) for safety evaluations of do-it-yourself (DIY) air cleaners
- Evaluated 5 commercial box fans with MERV 13 filters, 3 filter loading conditions:
  - Unloaded filter
  - Heavily loaded with dust (ASHRAE test dust)
  - Smoke loaded
  - Both sides of fan obstructed (tip over scenario)

Learn more at:

<https://www.epa.gov/air-research/research-diy-air-cleaners-reduce-wildfire-smoke-indoors>

TECHNICAL BRIEF



## A Strategic Research Initiative on Wildfires and Public Health

### Introduction

Raging wildfires pose significant economic, ecological and human health and safety threats. Wildfires have grown exponentially in the Western United States with millions of acres destroyed on an annual basis. Increasing arid climates, extreme temperatures and neglected forest management



Figure 1: The sky across San Francisco darkened on Sept. 9, 2020, and stayed orange during day as smoke from many wildfires across the state created a massive smoke cloud changing the sunlight to a perpetual orange glow. (iStock)

## RESULTS:

- No unsafe temperatures were measured in any condition
- Recommend using only NEW box fans (since 2012) with added safety features of fused plugs and thermal cutoffs



# Wildfire ASPIRE Study

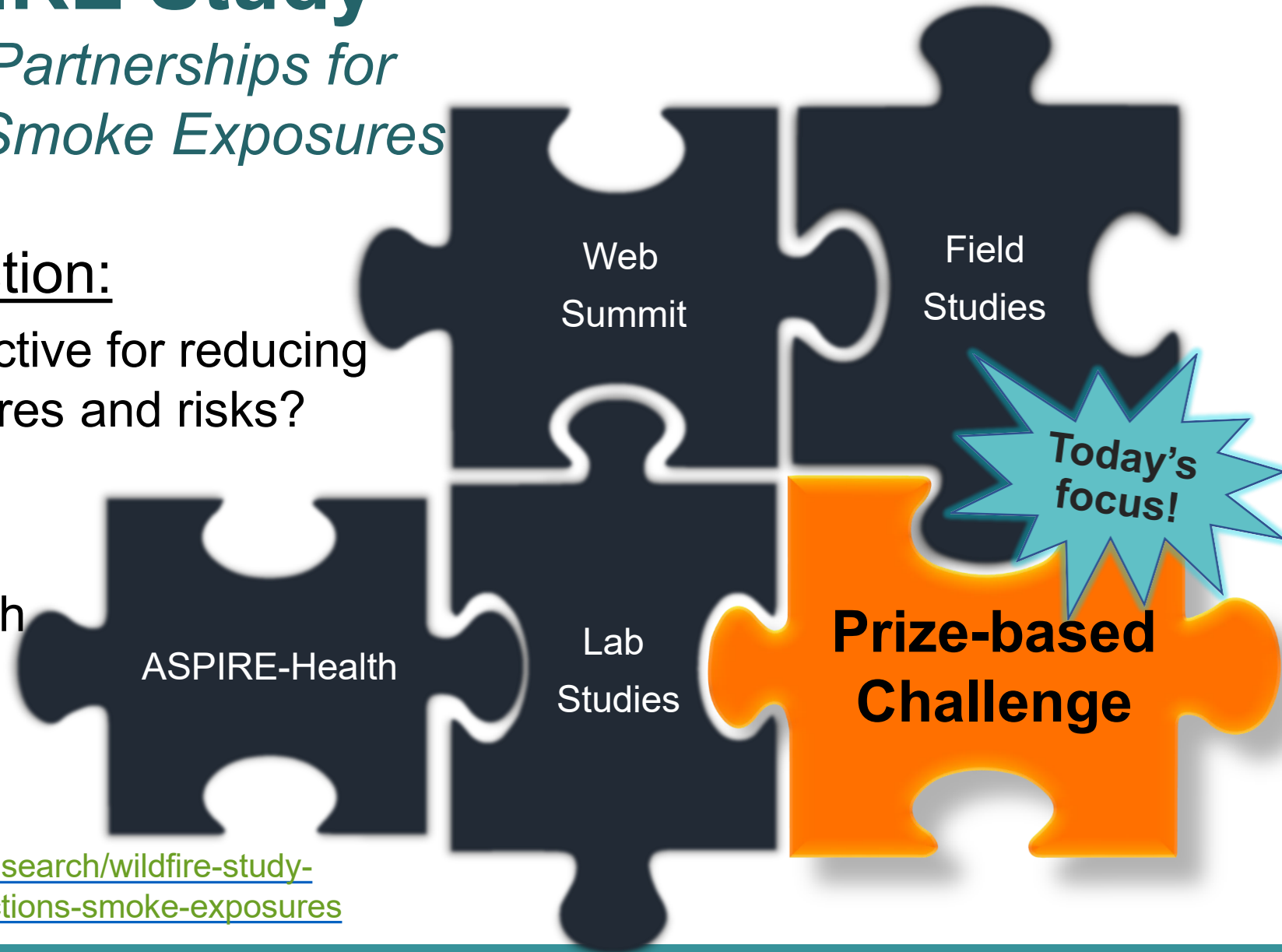
*Advancing Science Partnerships for Indoor Reductions of Smoke Exposures*

## Targeted Research Question:

- What interventions are effective for reducing wildland fire smoke exposures and risks?

## Primary Partners:

- Missoula City-County Health Department (MT)
- Hoopa Valley Tribe (CA)



Learn more at: <https://www.epa.gov/air-research/wildfire-study-advance-science-partnerships-indoor-reductions-smoke-exposures>



# Challenge Vision: Shared by 10 Partner Organizations

- Encourage development of new, effective, low-cost approaches to clean fine particulate matter (PM<sub>2.5</sub>) from indoor air, particularly during high concentrations due to smoke events or other high-pollution episodes
- Award a range of solution types to meet different needs: very low-cost, provides cooling, has an alternative power source







# Challenge Requirements

- Challenge included specific criteria:
  - **Must haves:** expected performance in removing PM<sub>2.5</sub> from indoor air; low- cost (less than \$100); low noise (less than 45 decibels); and safe to operate
  - **Additional desirable characteristics:** air cooling, sustainability, and operability during a power outage
- Detailed concepts submitted by Solvers in Phase 1 (2021)
- Submission of prototypes for evaluation in Phase 2 (2022)







# Challenge Phase 1 (Concepts)

May 17, 2021

>130

- Initial proposals submitted

45

- Completed proposals that fully addressed Challenge requirements sent to judging panel for review

5 + 3

- Highest-rated Solutions selected for awards
- 5 Winners, \$10,000 per proposal
- 3 Honorable Mention awardees (non-monetary)

Oct 26, 2021

## Wide range of types of Solutions received and reviewed:

- Adaptations of technologies used in industry
- Do-it-yourself (DIY) solutions
- And more...



# Challenge Phase 1 Results

## Winning Designs

- Low-Cost Household Air Purifier Requiring No Consumables
- Rutgers Research and Design Initiative (RRDI)
- The Cocoon: An Accessible Low-Cost Air Cleaner for Safer Spaces During Wildfires
- Resonant Ultrasonic Scrubber for Indoor Air Filtration
- Air2 Clear2

## Honorable Mention Awardees

- Metalmark Clean Air Device
- PM Shield
- Microporous Media for Airborne Pollutant Removal

Representatives from each team will briefly highlight the motivation for their solution and innovative components of their design.

WINNING CONCEPT

## Low-Cost Household Air Purifier Requiring No Consumables

The air purifier would use a method called cyclonic separation to remove smoke particles from the air and this process would be enhanced by adding a fine mist of water to the air stream.



# CHALLENGE WINNERS



Charlie Matlack



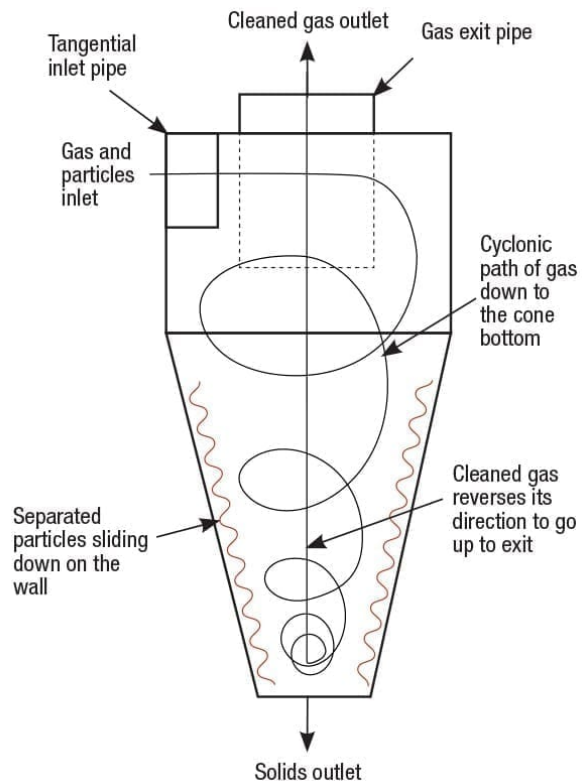
Liam Bradshaw

# How to clean air without a filter?

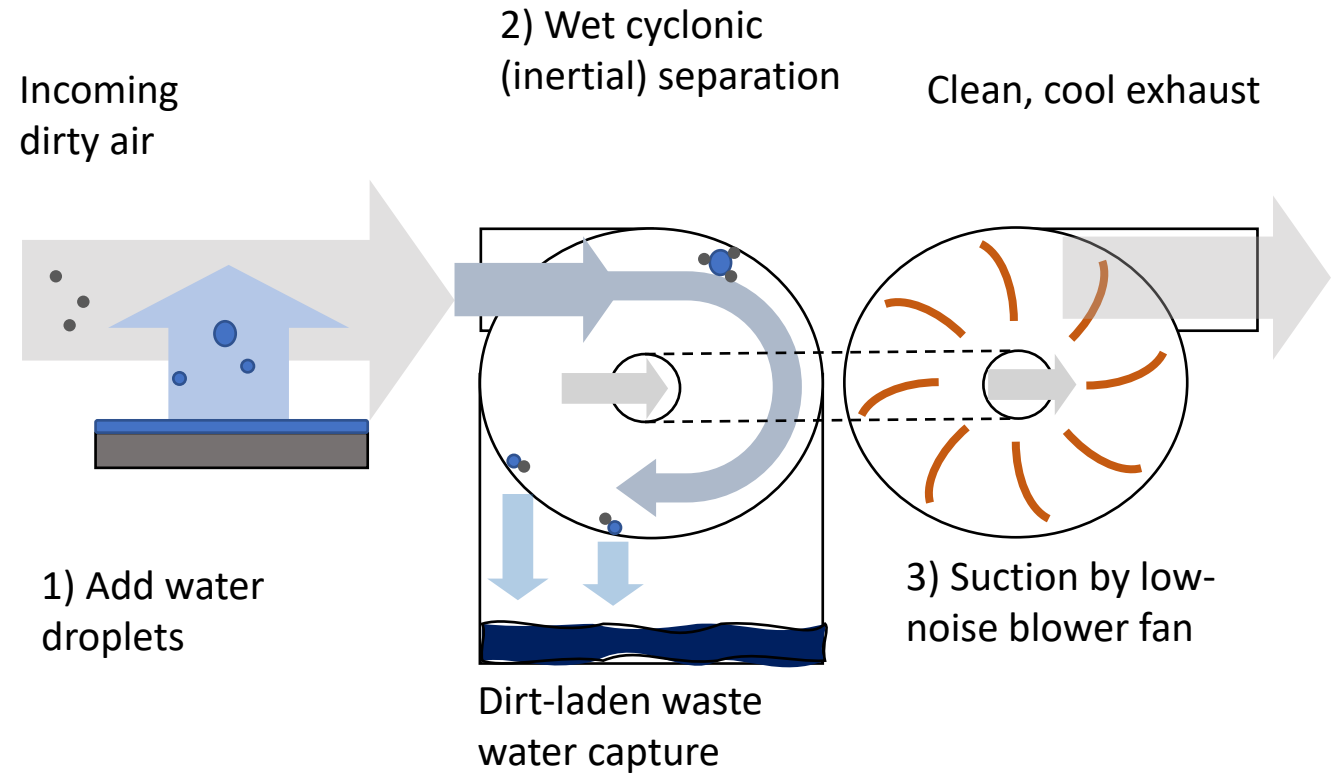
Dyson vacuum



Cyclonic separation

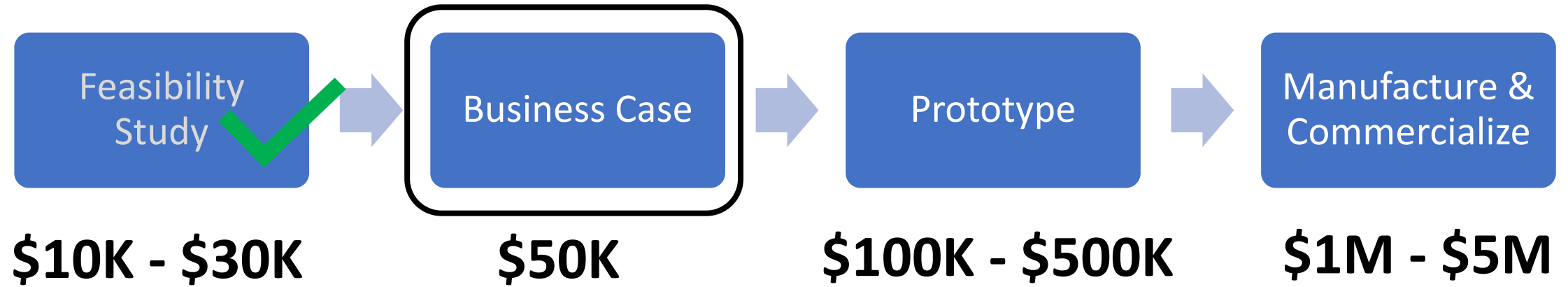


# The AirWasher



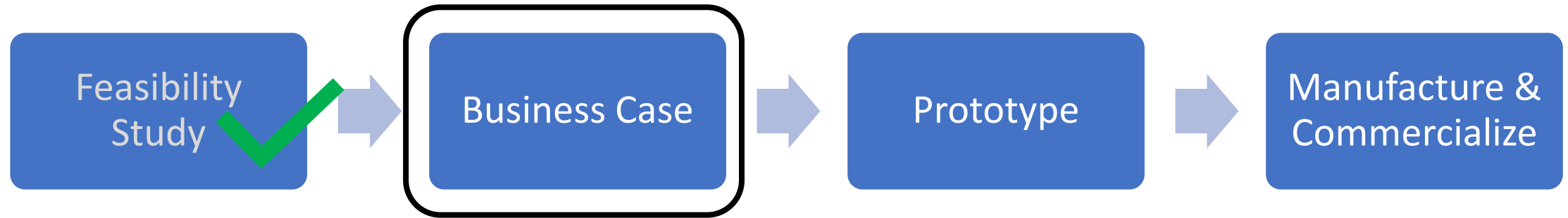


# Next Steps



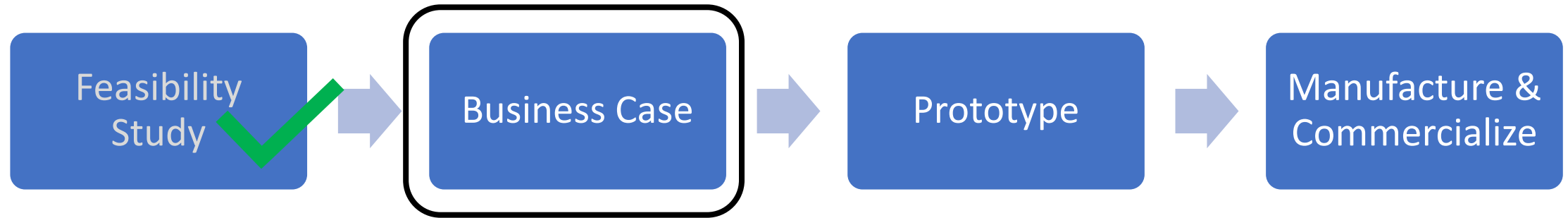
- There are already \$100 air purifiers on the market.
- During fire season, it's hard to buy any air purifier/filter in affected areas at any price, due to supply chain issues & consumers not planning ahead
- The *health need* needs to be translated into a *market solution*
- *Why isn't Dyson making a filter-less cyclonic separation air purifier?*

# Commercialization Challenges

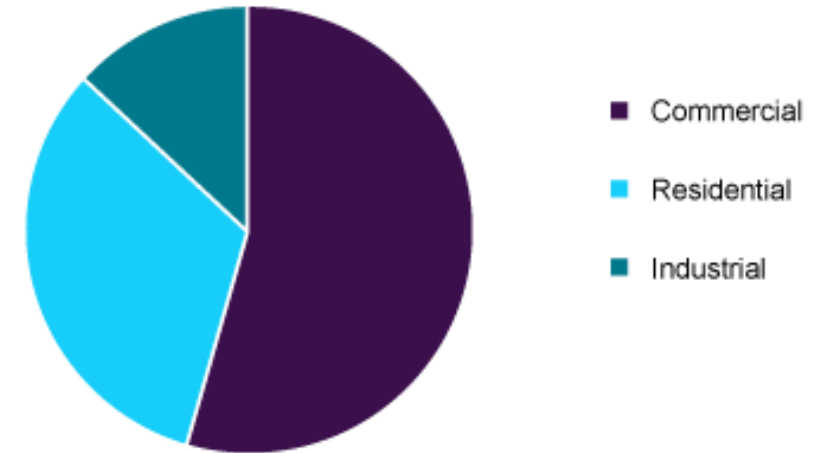


- Should the purifier have its own battery? Wireless/app capabilities? An air quality sensor to automatically turn on? These will cost more.
- Does it infringe on existing patents? Can it be patented? Takes >2 yrs!
- What certification is needed to promise consumers unique value of PM2.5 efficacy? Is MERV too broad (0.3-10um)?
- Launching a *retail consumer* product usually requires making 10,000's of them, shipping to retailers, then launching a big marketing campaign

# Market Assessment



- The US residential air purifier market is about \$1B, growing about 10%/year.<sup>1</sup>
- A new product capturing 1% of this would make \$10M in *revenue* per year, maybe \$1M *profit*
- Consumer behavior & market studies and aid with regulatory hurdles by EPA could help ensure product/market fit and success of a novel design



<sup>1</sup>June 2021 market research report by [ResearchAndMarkets.com](https://www.researchandmarkets.com) projects \$2.9B US market; 2019 report by [GrandViewResearch.com](https://www.grandviewresearch.com) shows about 30% of global market is residential.

## Rutgers Research and Design Initiative (RRDI)

A novel application of a commercial, industrial 2-phase wet scrubber modified for use in a home environment.



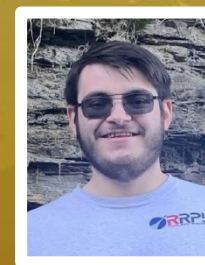
# CHALLENGE WINNERS



German  
Drazer



Edward  
Demauro



Alexander  
Sanducu



Lucas  
Hall



Jayesh  
Ratnam



Zeyneb  
Aamer



Aryanna  
Arcilla



Ismail Erdi  
Kurtyigit



Katherine  
Carley



Aris  
Karapiperis



Matthew  
Huang



Anish  
Seth



Maya  
Ziab

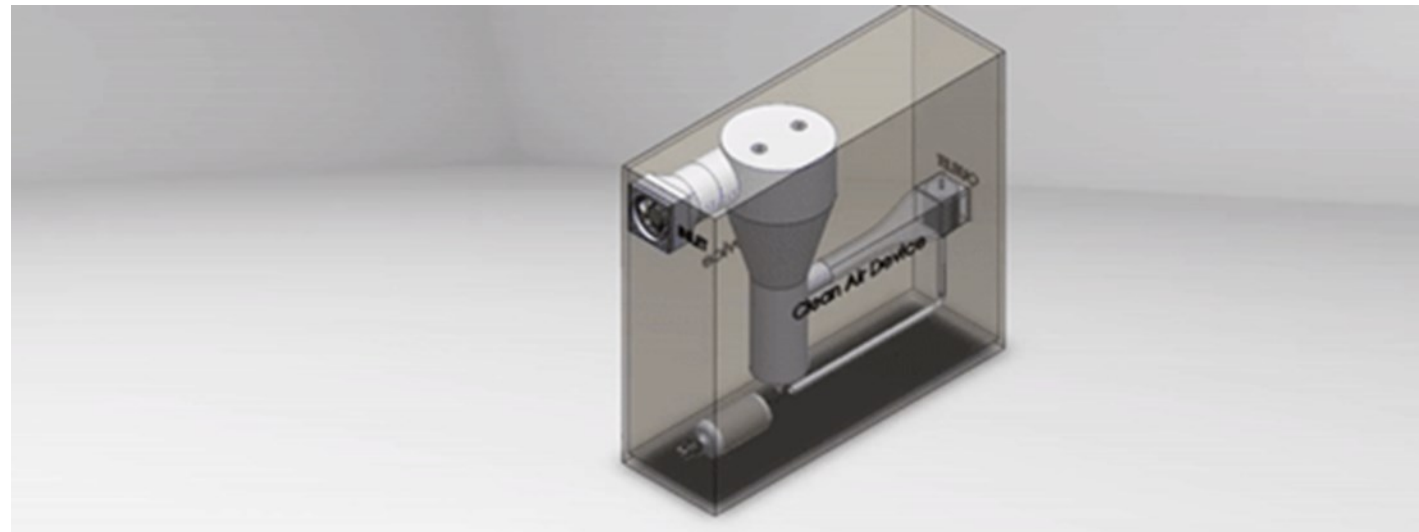
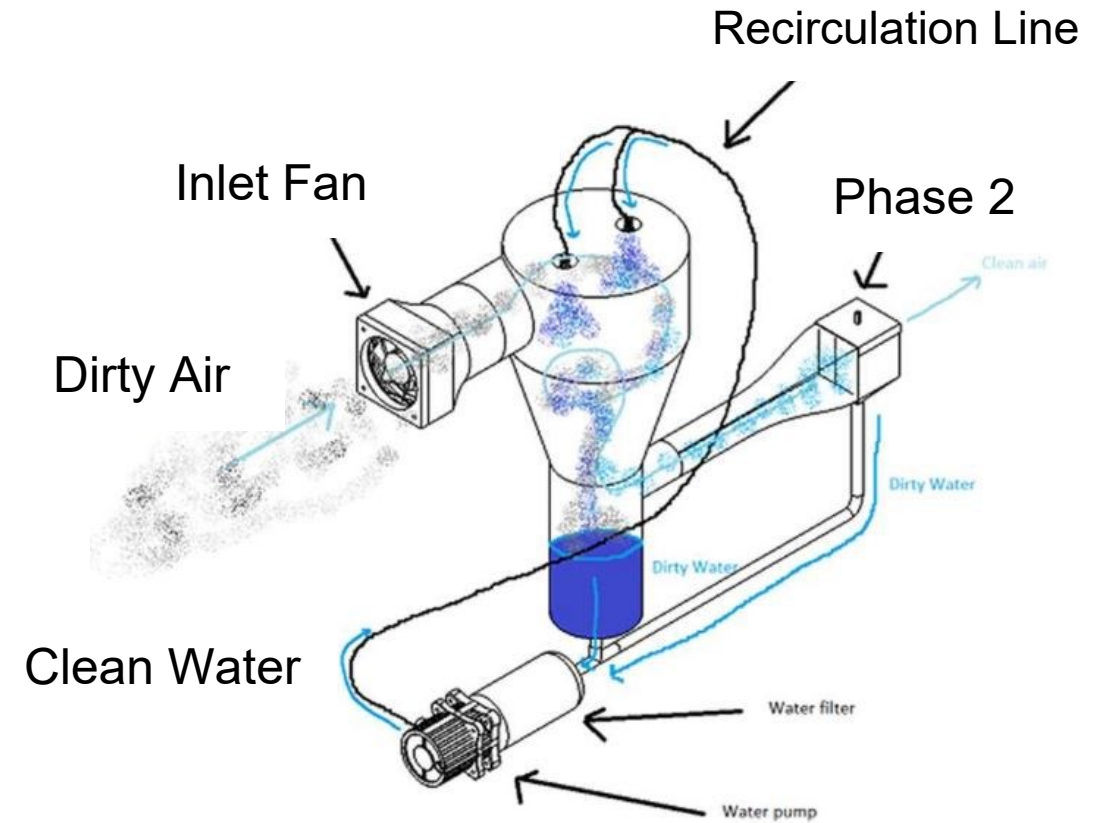


# Introducing: The Clean Air Device

With the danger that PM<sub>2.5</sub> wildfire smoke poses, the Clean Air Device was designed to offer an effective, affordable, and safe option for all those living near wildfire prone areas.

Two Phases:

1. “Wet scrubber”
2. Metal Wire Filter



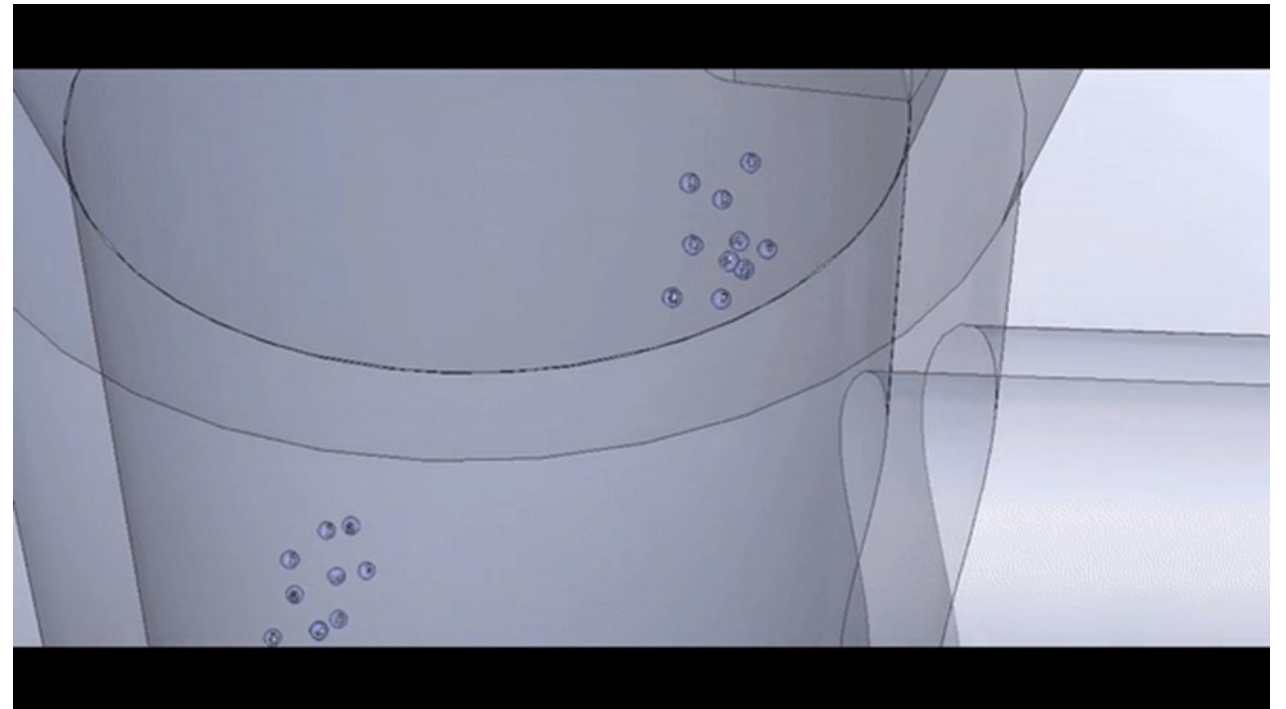
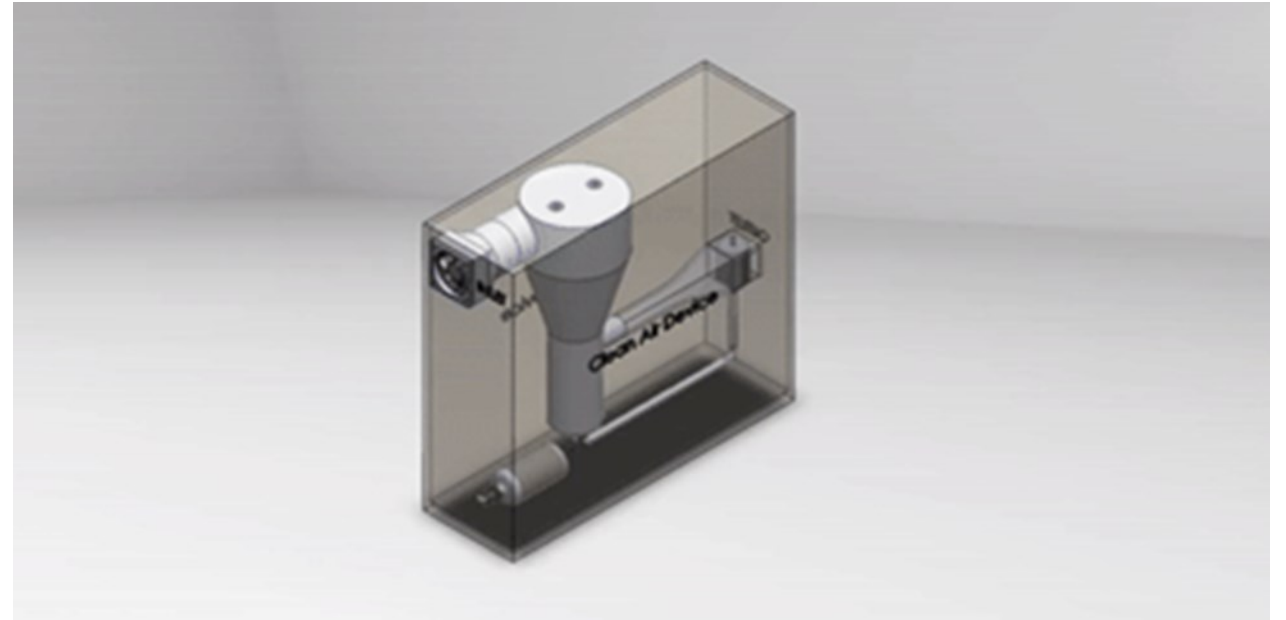
# Process Breakdown

## Phase 1

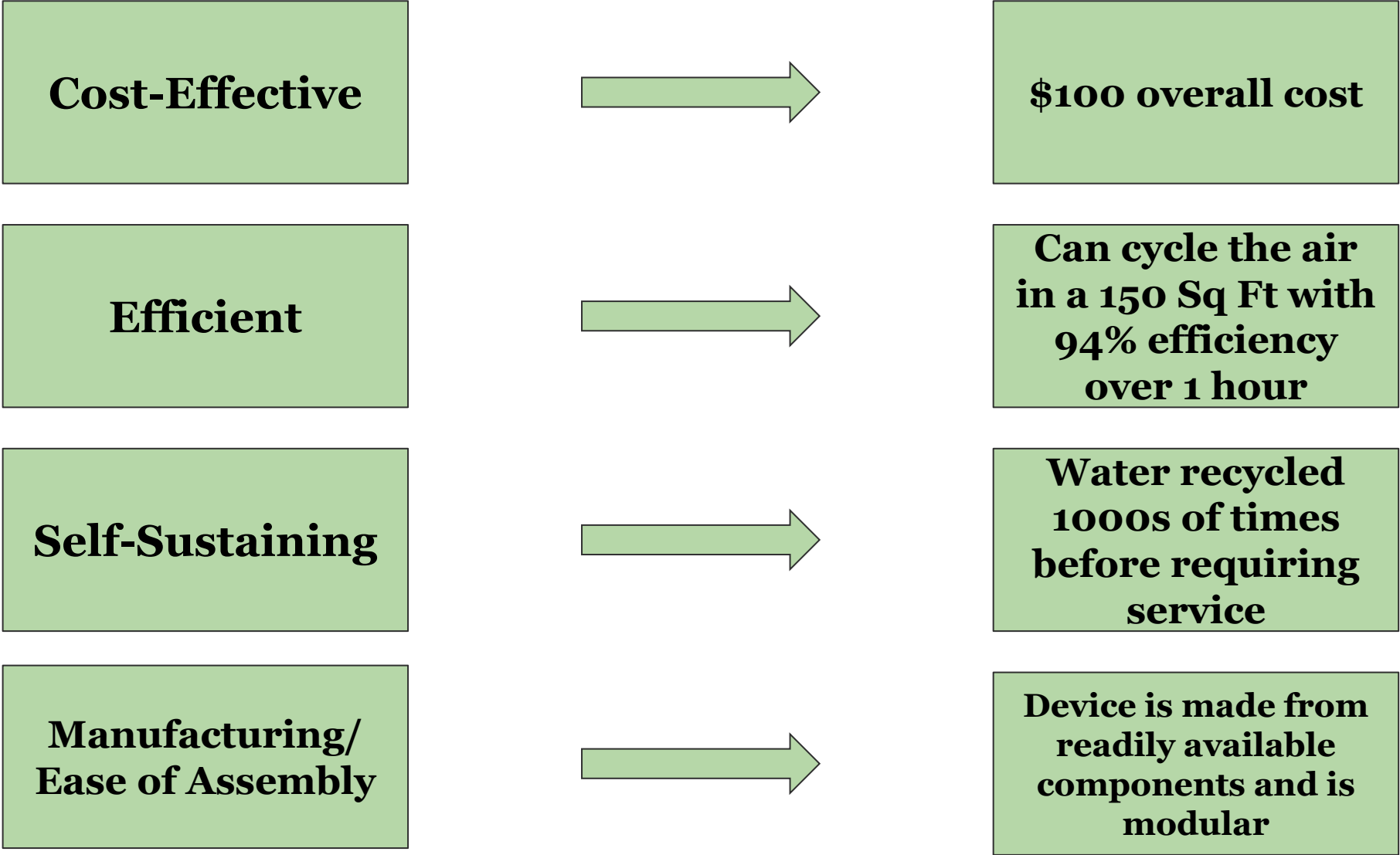
- Fine-mist water droplets sprayed over contaminated air
- Smoke particles embedded in water droplets
- ~ 70% of pollutants captured and removed from airstream
- Smaller particles are carried to phase 2

## Phase 2

- Contaminated droplets are captured through inertial impaction
- Rotating wire filter achieves 94% total capture efficiency of PM<sub>2.5</sub>
- Captured contaminated water is cycled through an activated charcoal filter



# Concluding Remarks



WINNING CONCEPT

## The Cocoon: An Accessible Low-Cost Air Cleaner for Safer Spaces During Wildfires

The Cocoon would use a large, tube-shaped, washable fabric filter combined with a box fan to create a low-cost device.



# CHALLENGE WINNERS



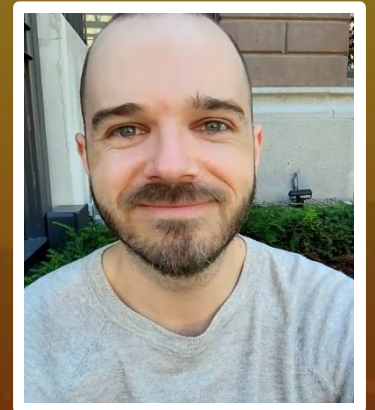
Elliott Gall



Brett Stinson



Matthew Moore



Warren Gunn

*Portland State University*



# The Cocoon: An Accessible Low-Cost Air Cleaner for Safer Spaces During Wildfires

Brett Stinson, Warren Gunn, Matthew Moore (presenting), and Dr. Elliott Gall

Dept. of Mechanical and Materials Engineering  
Portland State University



**The Cocoon is an air cleaner consisting of:**

- a box fan,
- a large “sock”-like fabric filter, and
- a strap or band

**The Cocoon is designed to be:**

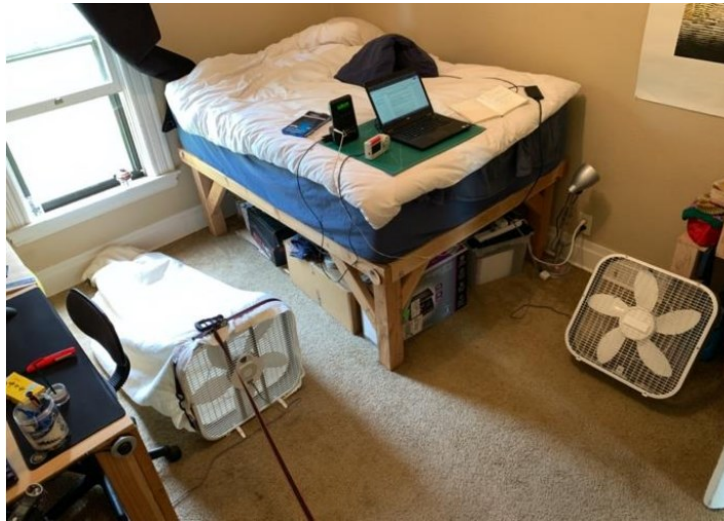
- **Effective:** > 80% PM<sub>2.5</sub> removed in 30 minutes
- **Inexpensive:** < \$60 if purchased new
- **Accessible & Resourceful:** household materials
- **Reusable:** fabric can be washed



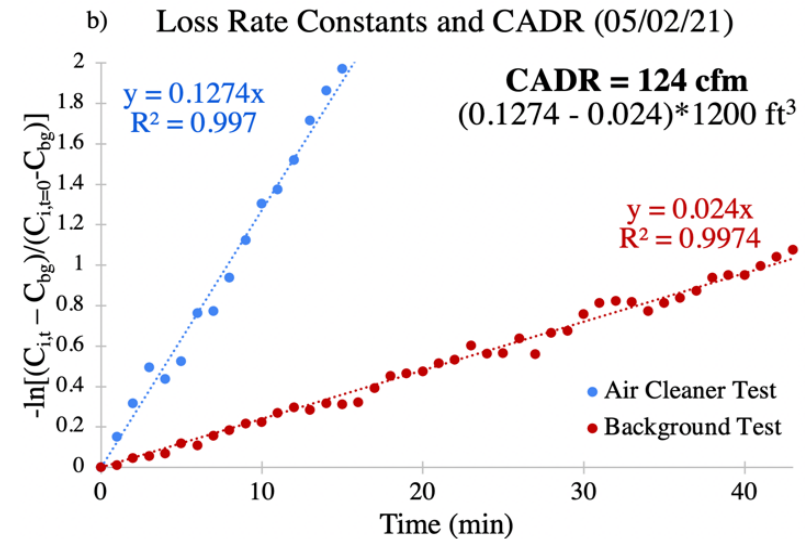
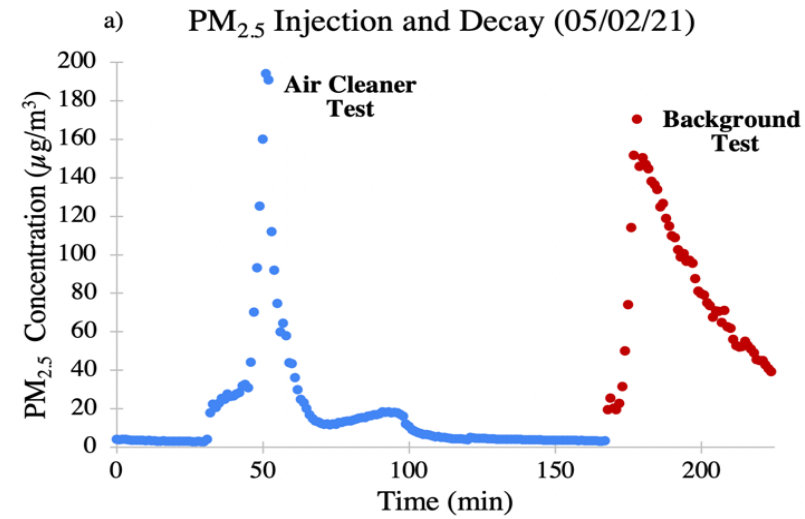
Healthy Buildings  
Research Lab



# Early results show effectiveness



Material	Cost
Box Fan	\$16 - \$23
Fabric (Cotton)	\$18 - \$25
Ratchet Strap	\$6 - \$12
<b>Total:</b>	<b>\$40 - \$60</b>





## Future goals

- Testing of other common fabrics
- Alternative methods of construction
- CADR with repeated washing
- Operation of device under various conditions
- Experimentally backed DIY guide
- CADR as function of particle size
- Testing of fabrics with activated carbon
- Scalable design for production



Scan the QR code with your phone's camera to learn more  
or contact Dr. Gall at [gall@pdx.edu](mailto:gall@pdx.edu)

WINNING CONCEPT

## Resonant Ultrasonic Scrubber for Indoor Air Filtration

The resonant ultrasonic scrubber would use the motion created by sound waves (ultrasonic agitation) to aerosolize water and mix with smoky air to capture particles in the air.



# CHALLENGE WINNER



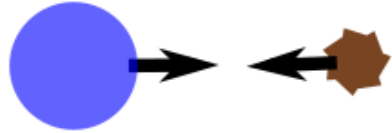
Eric Nutsch

*BOTE Innovations, LLC*

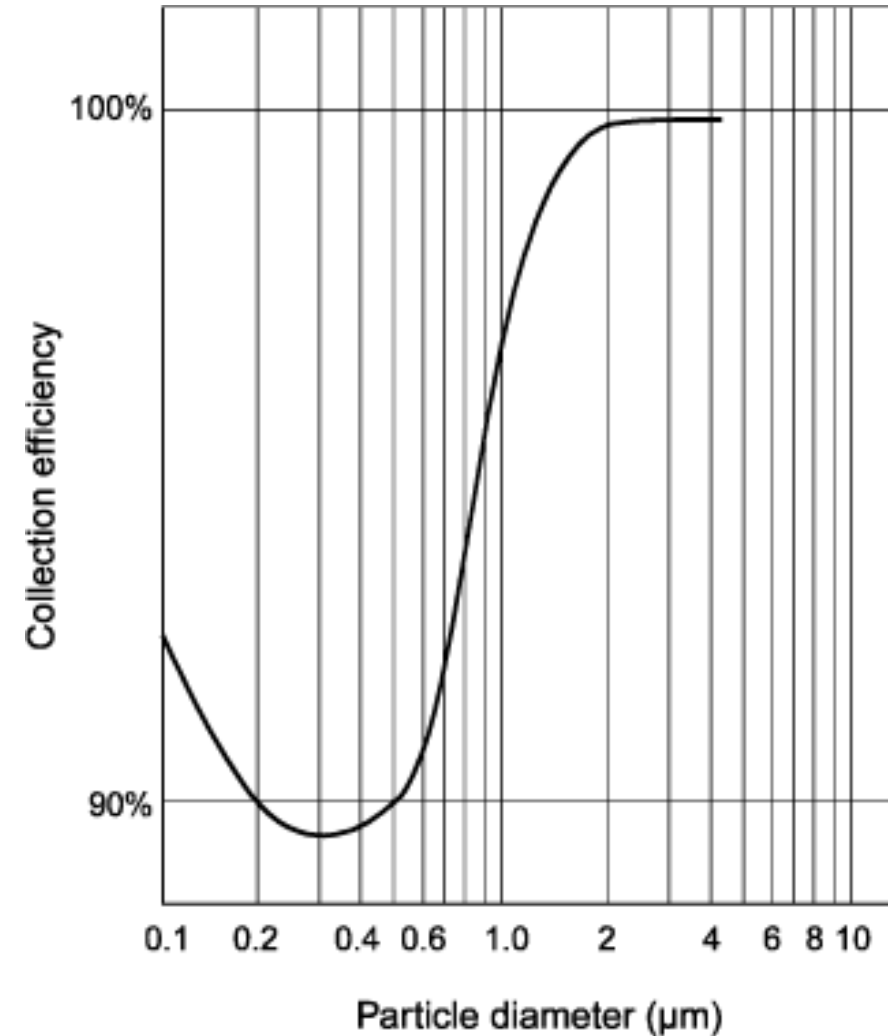
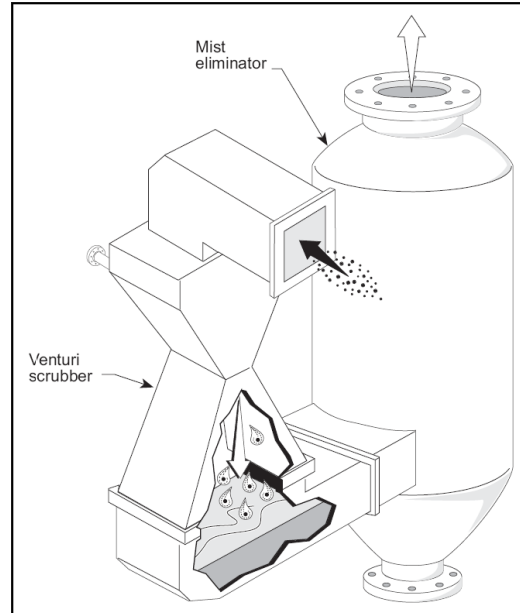


# Wet Scrubber Technology

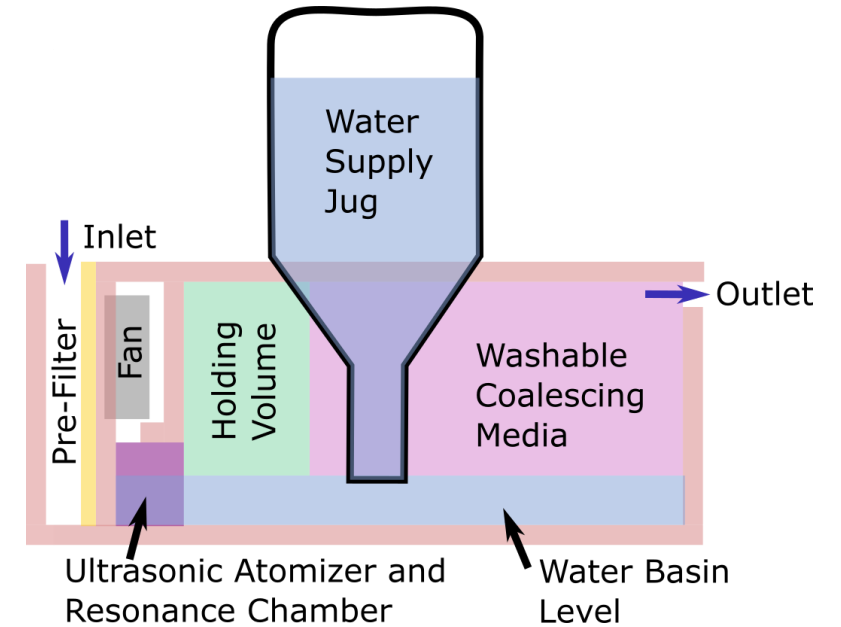
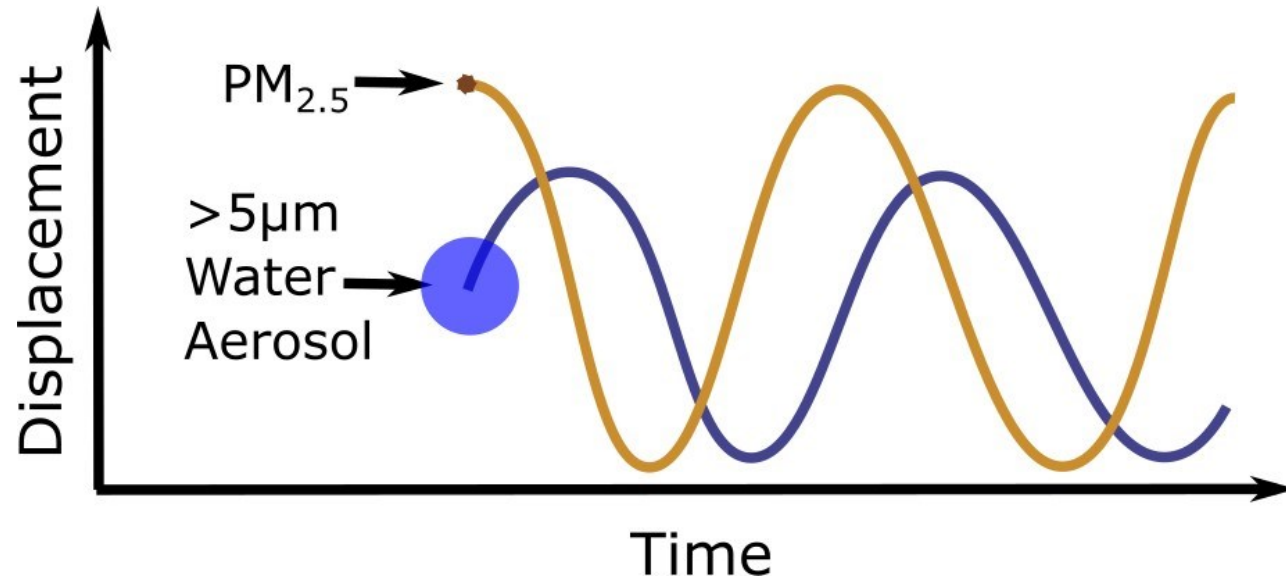
Impaction Mode  
for  $> 1\mu\text{m}$



Diffusion Mode  
for  $< 0.1\mu\text{m}$



# Ultrasonic Wet Scrubber Development





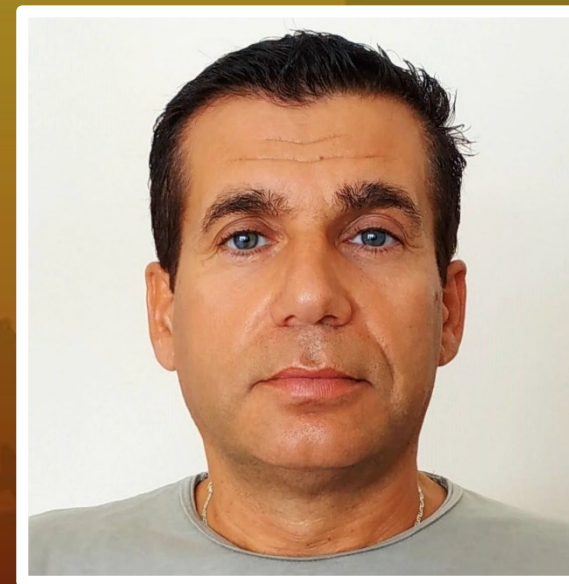
## Air2-Clear2

The Air2-Clear2 would be a filterless, extraction-based air cleaner using a high-flow fan to force air through a series of barriers to collect particulate matter.

# CHALLENGE WINNERS



Zeljko Prijovic

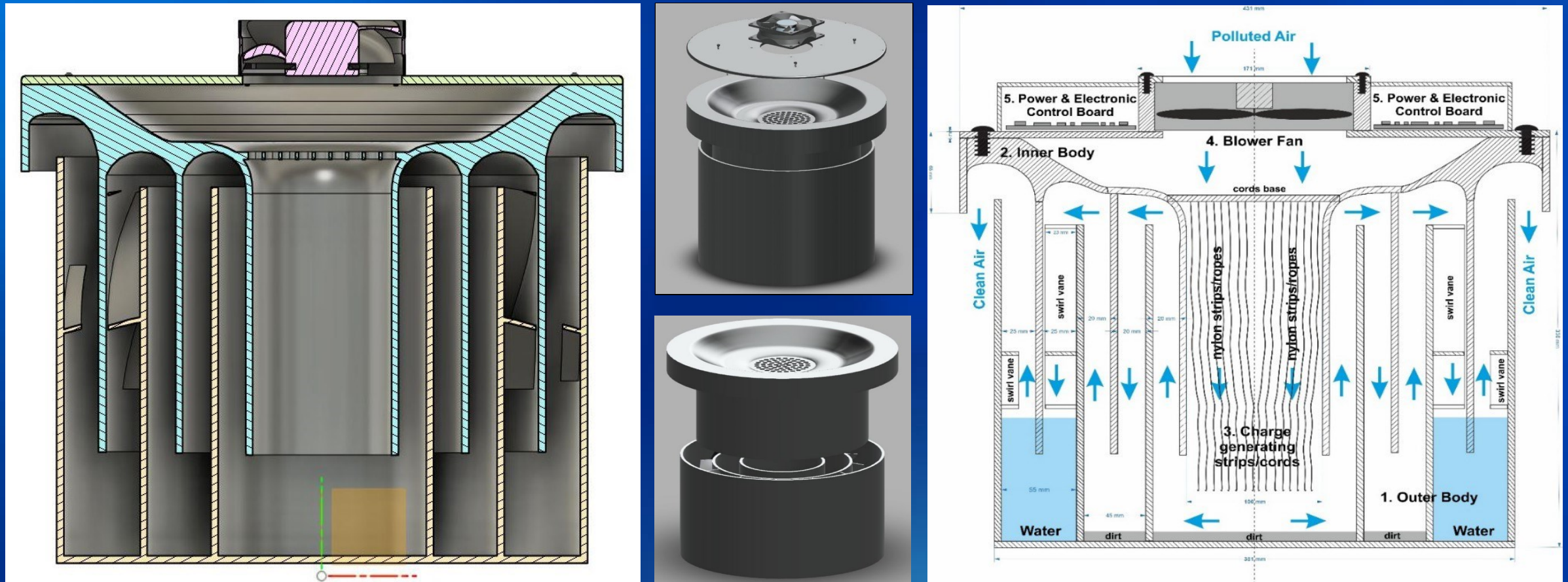


Emil Valchinov

# A Dynamic Extraction-Based Air-Cleaner without Classic Filters "Air2-Clear2"

October 2021

Zeljko Prijovic, PhD, *Belgrade, Serbia* and Emil Valchinov, PhD, *Pazardzhik, Bulgaria*

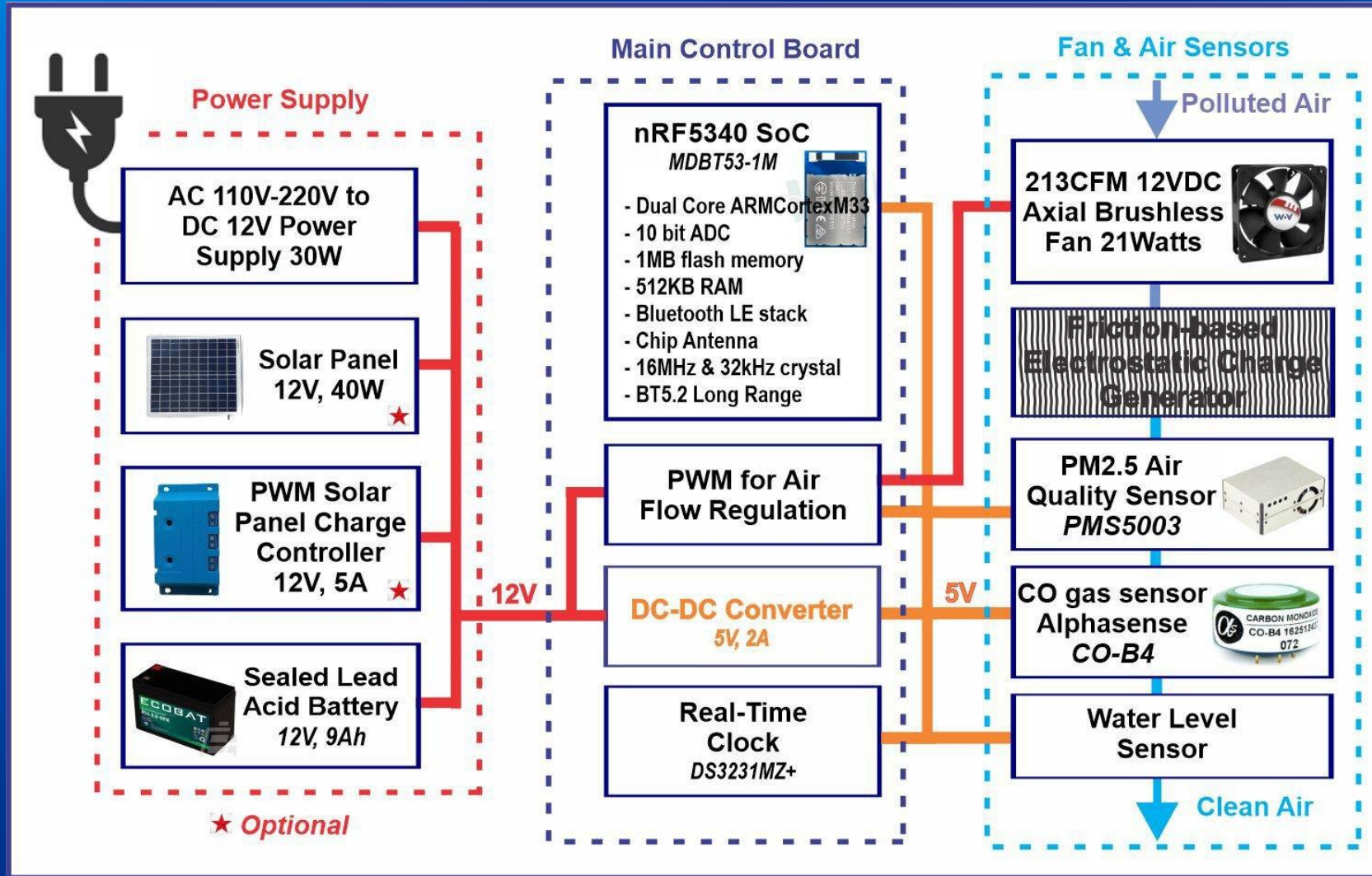


3D model cut-out and mechanism of operation





# A Dynamic Extraction-Based Air-Cleaner without Classic Filters “Air2-Clear2”



Block diagram of the proposed filtration device



## S U M M A R Y

- ❑ The device is intended to reduce the coarse and fine particles of natural or man-generated hazardous material and gasses from indoor air to the acceptable level at low cost and generating no additional waste.
- ❑ Based on a modular principle, it may be upgraded or modified to accommodate the different needs of the customers or the nature of the pollutants.
- ❑ It can operate at an extremely broad range of conditions regarding temperature and humidity, possessing no risk to human health, fire hazard, or generating any additional pollution.
- ❑ Optionally, special electronics may be included if/where needed, to control the device, monitor, and signals the air quality, but the device will be fully operable without it.
- ❑ Overall, with its simple design, expected high efficiency, low cost, easiness to operate, and no impact on the environment, we consider this device with high potential for application in emergencies where air quality is compromised.

Zeljko Prijovic

[zmpsunny@eunet.rs](mailto:zmpsunny@eunet.rs)

Belgrade, Serbia

Do you have any questions?

# Thank you!

Emil Valchinov

[evalchinov@gmail.com](mailto:evalchinov@gmail.com)

Pazardzhik, Bulgaria

## Metalmark Clean Air Device

The device would use a novel nanomaterial coating on a filter to enable destruction of captured particulate matter when the filter is heated to high temperature.



# HONORABLE MENTION



Sissi Liu



Tanya Shirman



Elijah Shirman

*Metalmark Innovations, Inc.*



## Metalmark's Air Purification Solution

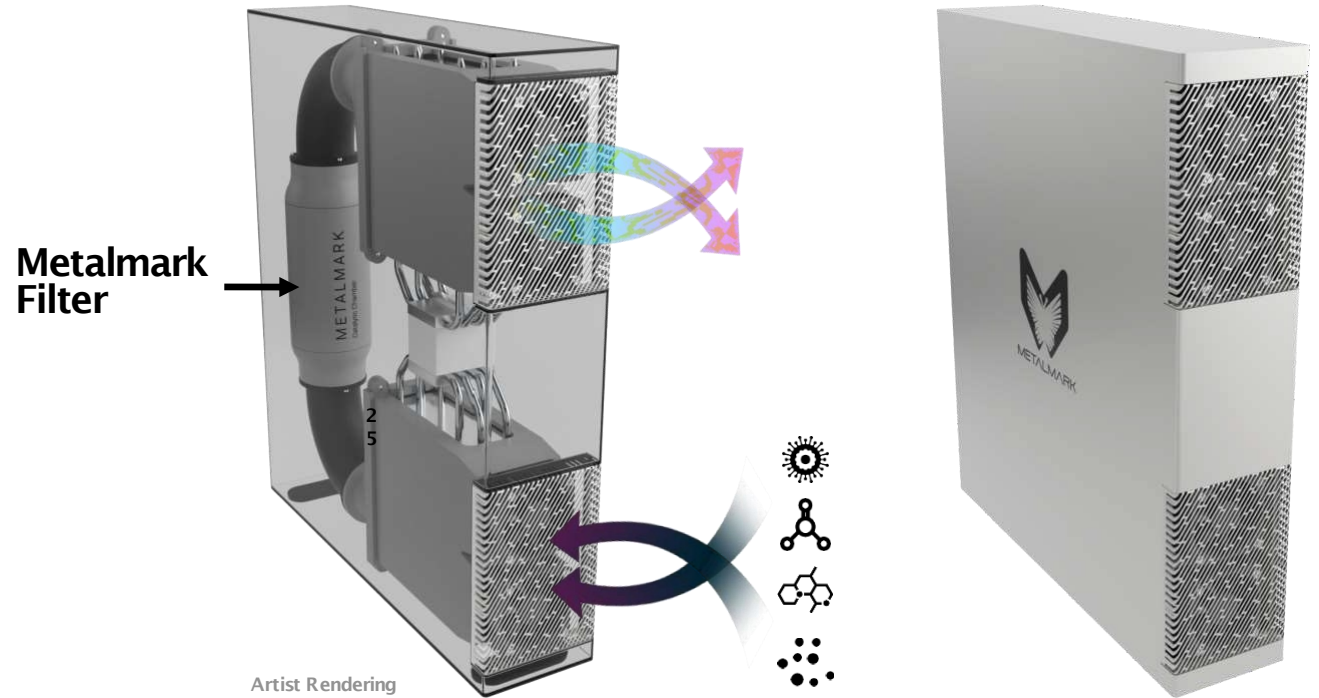
We're developing the world's 1st self-renewing air purification system that removes & destroys **Wildfire Smoke Particulates & Pathogens.**

### 1. Filtrate

Metalmark's nanostructured porous coating targets arrestance of submicron organic pollutants.

### 2. Renew

Metalmark system activates catalytic material by elevating the filter core temperature to destroy captured organic pollutants and pathogens.



#### > High Efficacy

95+% Single-Pass Efficiency

#### > Low Maintenance Cost

1/10 HEPA Filter Replacement,  
Energy Efficient Operation

#### > Safe

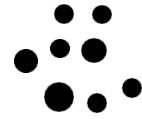
No Harmful Byproducts,  
Ozone, Ions, Radicals, or UV

#### > Good For The Planet

Eco-Friendly & Durable  
Material, Filter Reactivation



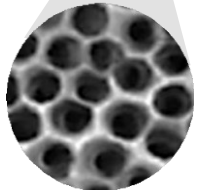
# Metalmark Inside | 3D Nanostructured Material



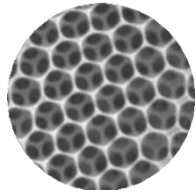
Organic PMs



Pathogens



Biological Model



Metalmark's Synthetic Framework

Clean Air

Metalmark material arrests & catalytically destroys pollutants to produce clean & safe air

Metalmark Material

Nanoparticles

NOTABLE CONCEPT

## PM Shield

This air cleaning solution would be a kit for installing a fan in a window, bringing in filtered air, and creating enough positive pressure indoors to prevent infiltration of smoke through other cracks or openings.



# HONORABLE MENTION



Cliff  
Edwards



Oscar  
Malpica



Geoffrey  
Edwards



Chuck  
Lee



Mahmoud  
Rezaee



Warren  
Stiver

*Envisioning Labs*

ENVISIONED CONSUMER KIT

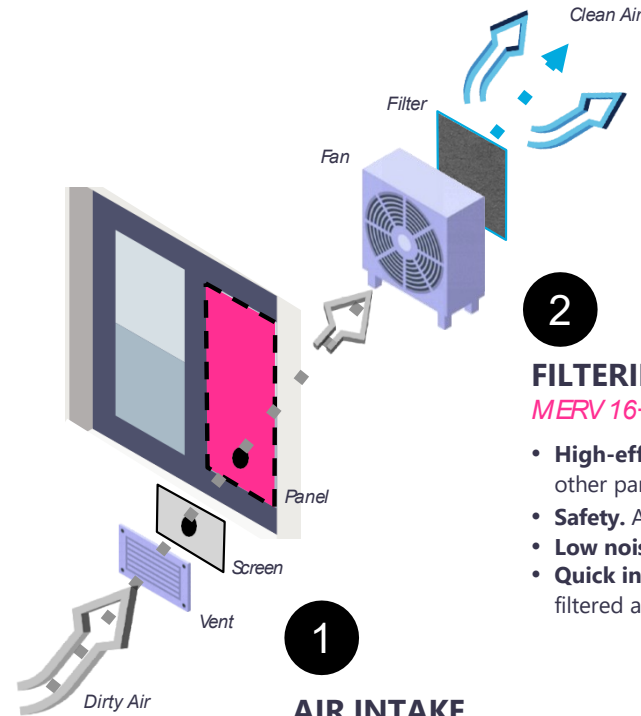
# PM Shield

Filtered, Positive Pressure for  
Cleaner Indoor Air During Wildfires



## PM SHIELD

Cleaning air coming in, while pushing dirty air out.



3

### POSITIVE PRESSURE

*Effective commercial technique*

- **A whole home solution.** The positive pressure of filtered air inside keeps particulates out.
- **Fan speed is controlled,** optionally automatically, to maintain slightly increased pressure inside.
- **Solution adaptable** to a wide range of homes.

2

### FILTERING

*MERV 16+ or HEPA rated*

- **High-efficiency filter.** A furnace style filter traps smoke and other particulates as air is blown inside.
- **Safety.** A screen on the outside prevents fan blade contact.
- **Low noise.** Filter on inside reduces fan noise.
- **Quick indoor air cleansing.** Complete home air exchange for filtered air in ~30 minutes to 2 hours.

1

### AIR INTAKE

*Filter and fan window kit installed in single window*

- **Simple approach.** Outdoor air is pushed inside through a filter by a fan, both mounted as part of a window installation kit.
- **Low cost.** starting at \$55 USD for materials, MSRP: \$99.99
- **Low energy.** Less than 1kWh electrical consumption per day. Optionally solar powered.

# PM Shield

Filtered, Positive Pressure for Cleaner Indoor Air During Wildfires



See it in action:  
<https://youtu.be/-5nNGlhjAps>

[info@envisioninglabs.com](mailto:info@envisioninglabs.com)  
[www.envisioninglabs.com](http://www.envisioninglabs.com)



## PROTOTYPE TEST

- 1,750 sqft house (*leaky envelope*)
- 4 bedrooms, 2 bathrooms
- 1 x Fan (460 CFM)
- 1 x Filter (MERV16)

**10 min to Positive Pressure**

with whole home protection from external PM intrusion.

## BENEFITS

- **300-450 CFM fan**  
*OK for PP in most homes*
- **30 - 120 min Air Exchange**  
*per 1000 sqft*
- **Less than 40W power consumption**  
*(< 1 kWh energy per day)*

## CONSUMER OPTIONS

	TIER 1 AC Powered	TIER 2 Daytime off-grid power	TIER 3 24x7 off-grid power
	PP Fan + Filter Kit	PP Fan + Filter Kit	PP Fan + Filter Kit
	AC Power Adapter	AC Power Adapter	AC Power Adapter
		1 x Solar Panel + Cable Kit	2 x Solar Panel + Cable Kit
			Battery + Charge Controller
Cost of Materials	\$55	\$82.5	\$155
<b>Retail Price</b>	<b>\$99.99</b>	<b>\$154.99</b>	<b>\$299.99</b>



## Microporous Media for Airborne Pollutant Removal

A device using a washable, reusable pellet to filter out particulate matter from air passed through it by a small fan.



Stephen Grunzinger  
*Idea Forge, LLC*

**HONORABLE  
MENTION**



# Microporous Media for Airborne Pollutant Removal

Dr. Stephen Grunzinger Idea Forge

## Proposal for EPA

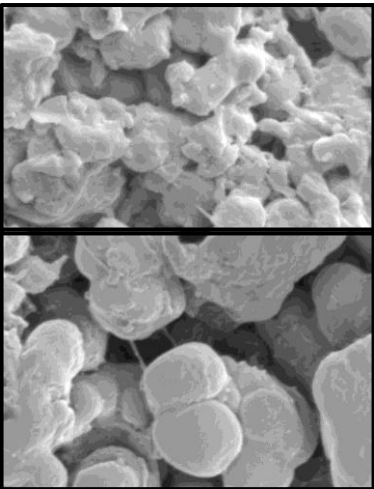
Use the porosity of our material to trap and eliminate pollutants.

Our microporous PVC is an easily manufactured material where the pore size can be tailored to trap wildfire ash and other particle pollutants and remove them from the air. The microporous PVC can also be formulated with material that can absorb and eliminate VOCs generated by wildfires and other industrial processes.

Idea Forge wants to be your collaboration partner for filtration material

- Easy to manufacture at scale (extrusion)
- Control over amount of porosity.
- Holds moisture for evaporative cooling
- Creates adiabatic cooling
- Noise reduction
- Post manufacture modifiable
- PVC is chemically inert and non-flammable
- Developed and produced in Minnesota, USA

# Customizable Formulations



Controllable Porosity



Unfilled



MnO<sub>2</sub>-filled



Activate Carbon-filled



Fe<sub>2</sub>O<sub>3</sub>-filled



Video Demonstration  
- Cooling Effect  
- Particle Accessibility

Dr. Stephen Grunzinger  
[ideaforgellc@gmail.com](mailto:ideaforgellc@gmail.com)  
651-321-1808  
<http://ideaforge-llc.com/>  
2000 Industrial Blvd.  
Stillwater, MN 55082



# Questions?



Smoke plumes over Missoula, MT Aug 2017

Learn more about the ***Cleaner Indoor Air During Wildfires Challenge*** and Phase 1 winners at:

<https://www.epa.gov/air-research/cleaner-indoor-air-during-wildfires-challenge>