

Trane: Improve Air Quality VDR 2

Jake Hamilton, Nicholas Holm, Andreu Santeiro, Joseph Thyer, Gavin Young



Team Introductions



Jake Hamilton
*Design
Engineer*



Nicholas Holm
*Environmental
Engineer*



Andreu
Santeiro
*Quality Control
Engineer*



Joseph Thyer
*Project
Management
Engineer*



Gavin Young
*Fluids
Engineer*

Gavin Young

Sponsor & Advisor



Engineering Mentor
Cameron Griffith
Trane Liaison



Academic Advisor
Juan Ordonez, Ph.D.
*Energy Conversion Systems
Director & Professor*

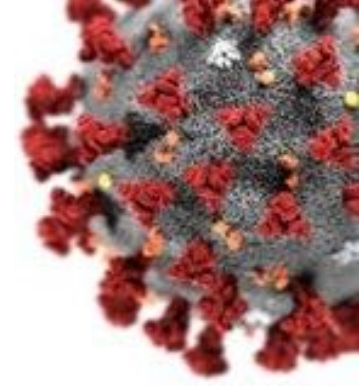
Gavin Young

Objective

Develop a strategy to improve indoor air quality that combats COVID and has significant long term usefulness.

Gavin Young





Background

Gavin Young



Key Goals

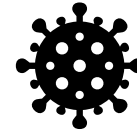
Improve Air
Quality

Promote
Sustainability



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Pollutant Categories



Biological

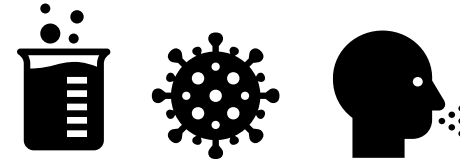
Chemical

Particle

Gavin Young



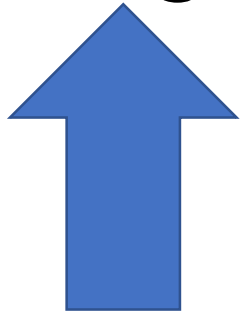
Pollutant Categories



Biological

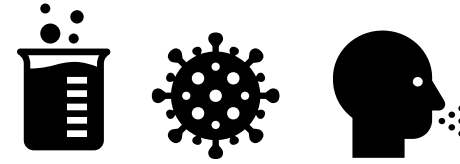
Chemical

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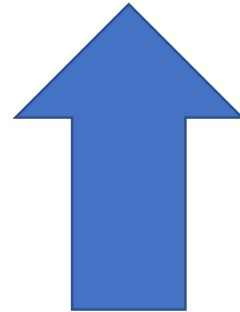
Pollutant Categories



Biological

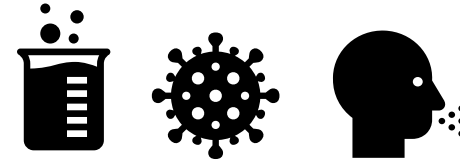
Chemical

Particle



Gavin Young

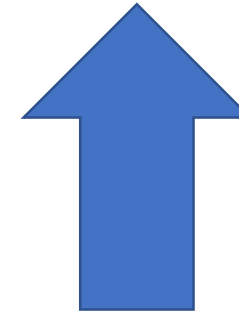
Pollutant Categories



Biological

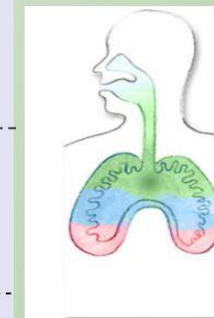
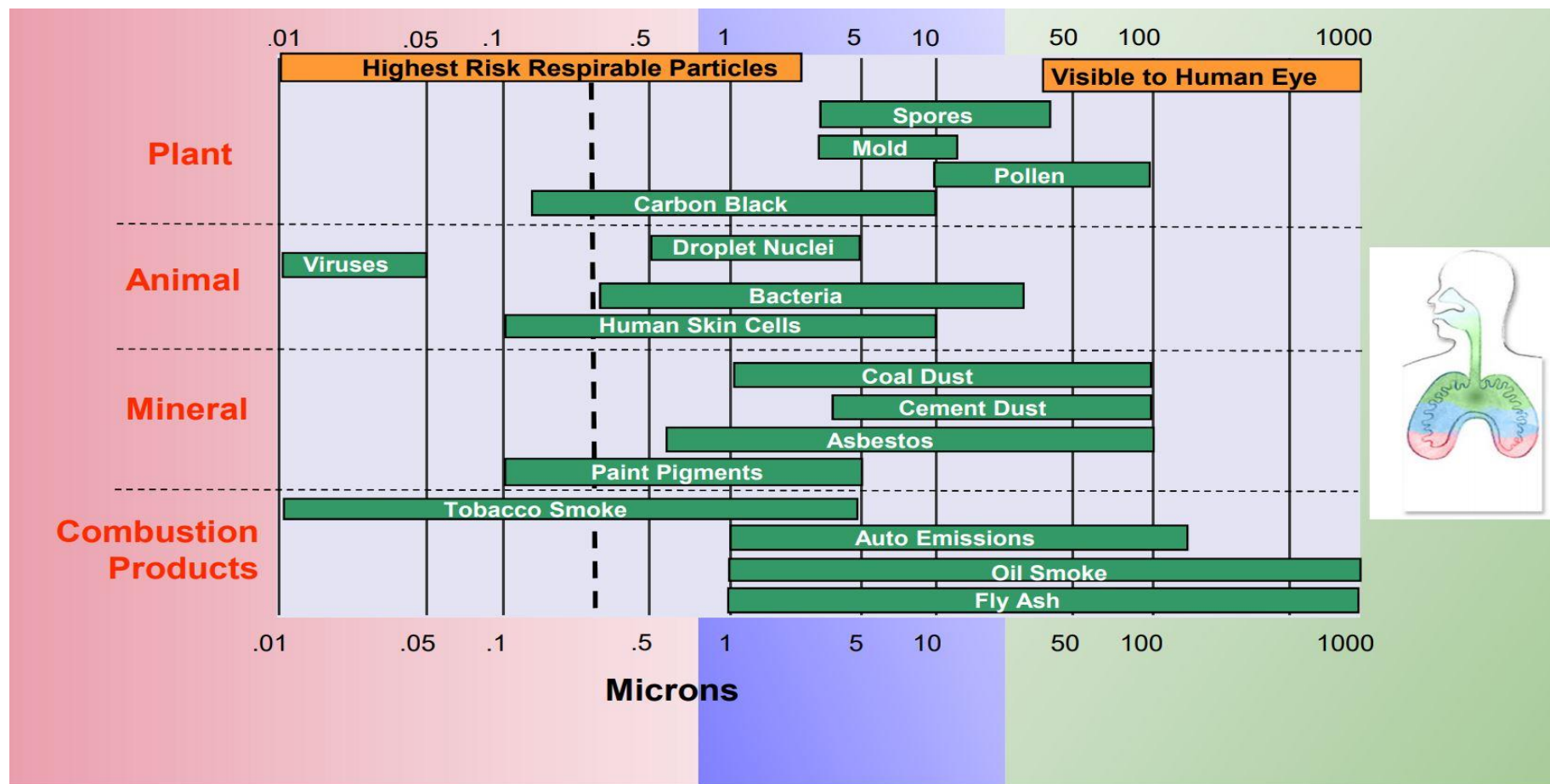
Chemical

Particle



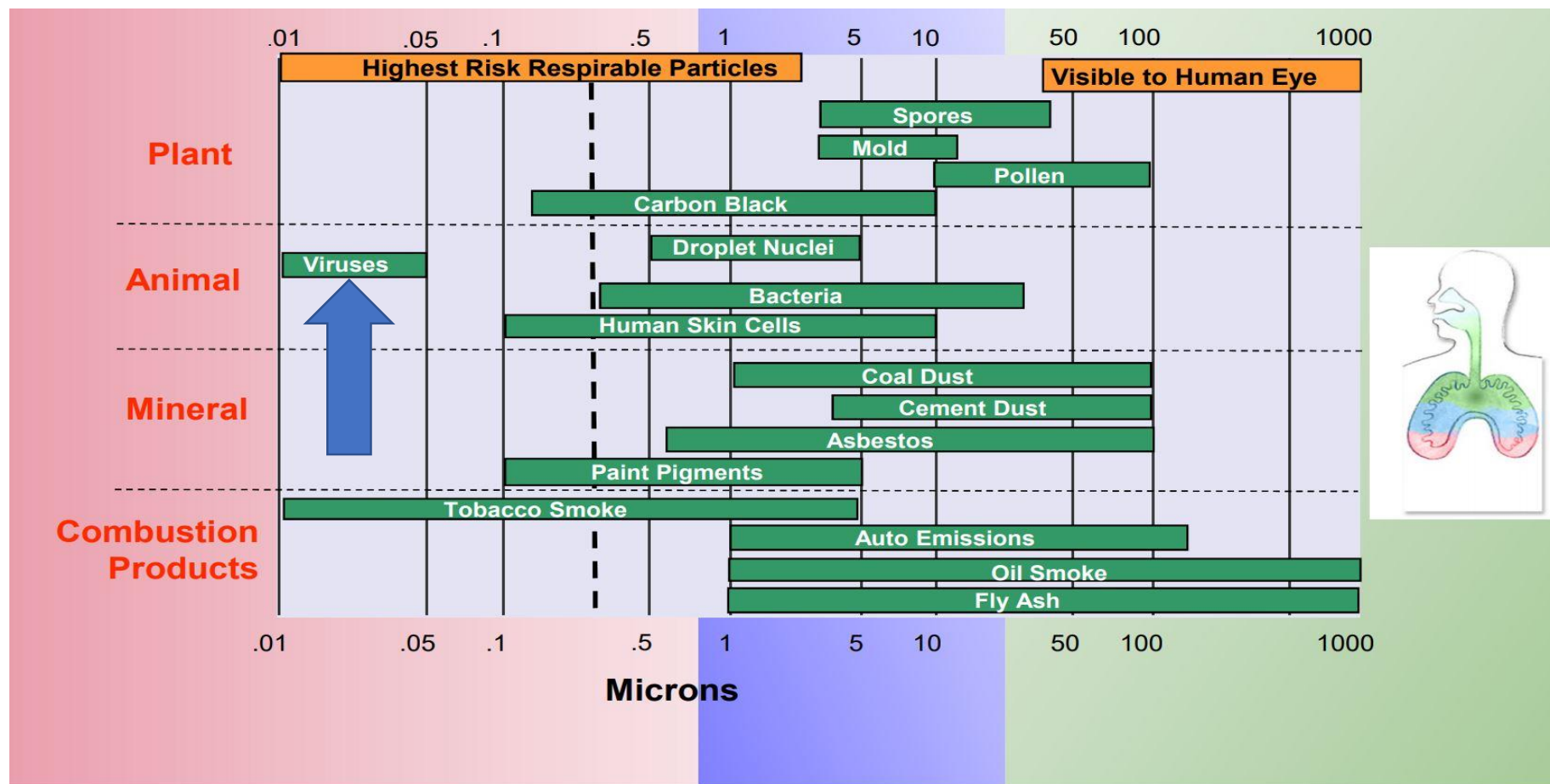
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Particulate Sizes



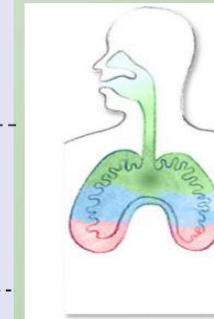
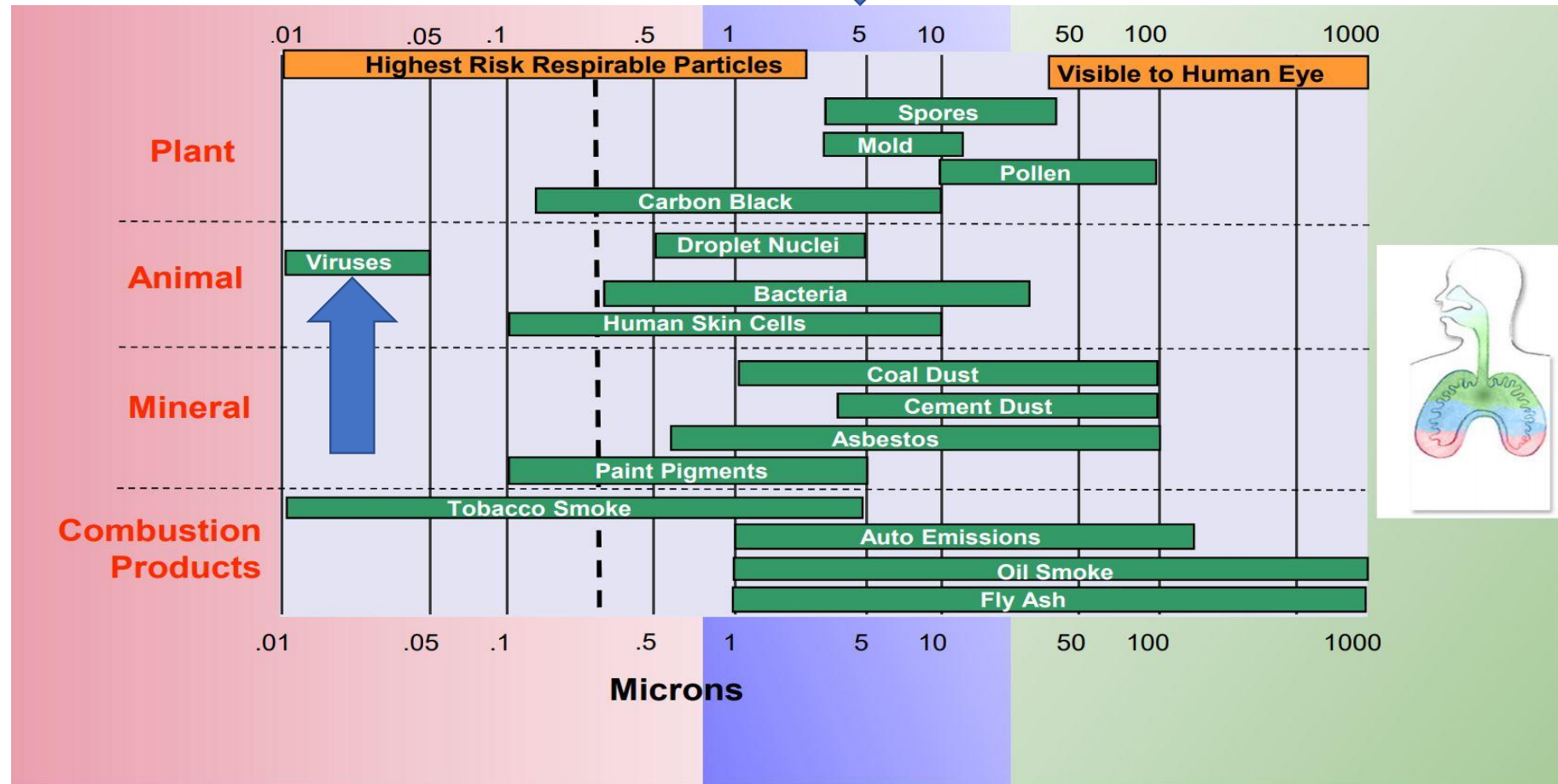
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Particulate Sizes



Gavin Young

Particulate Sizes



Gavin Young

Customer Needs

- Improve air quality
- Minimize operating costs
- Remains useful into the future
- Promote Trane's ideals



Nicholas Holm

Critical Functions

- Improve Air Quality
 - Clean Indoor Air
 - Dilute Indoor Air
 - Exhaust Indoor Air
 - Contain Indoor Air
- Minimize increase in energy usage

Air Quality Index - Particulate Matter	
301 – 500	Hazardous
201 – 300	Very Unhealthy
151 – 200	Unhealthy
101 – 150	Unhealthy for Sensitive Groups
51 – 100	Moderate
0 – 50	Good

Nicholas Holm

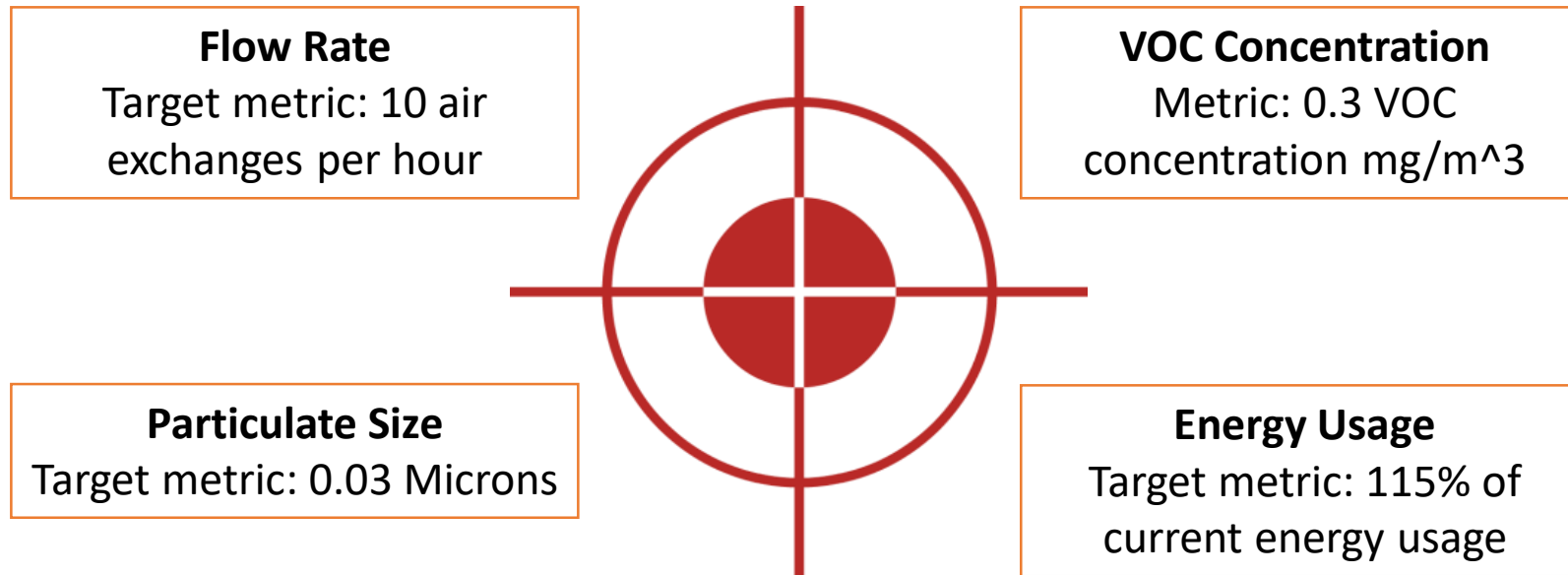
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Nicholas Holm

Targets and Metrics



Nicholas Holm

Concept Generation

Nicholas Holm



Concept Selection

Joseph Thyer



Ionization

- Uses high voltage to charge particles
- Makes particulate easier to filter
- Proven on industrial scale



Joseph Thyer

Ionization cont.

- Ionization can generate Ozone
- Needlepoint Bipolar Ionization (NPBI) does not
- Works on particles of all sizes



Joseph Thyer

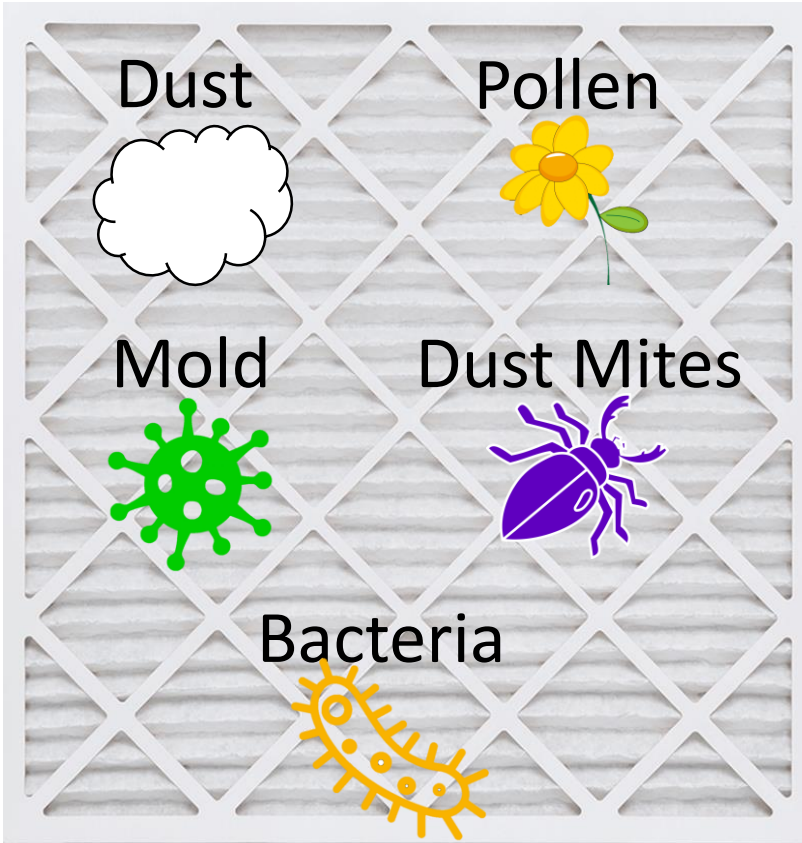
Higher Quality Filters

- Works for lots of systems, but not all
- Easy installation
- Replacement costs

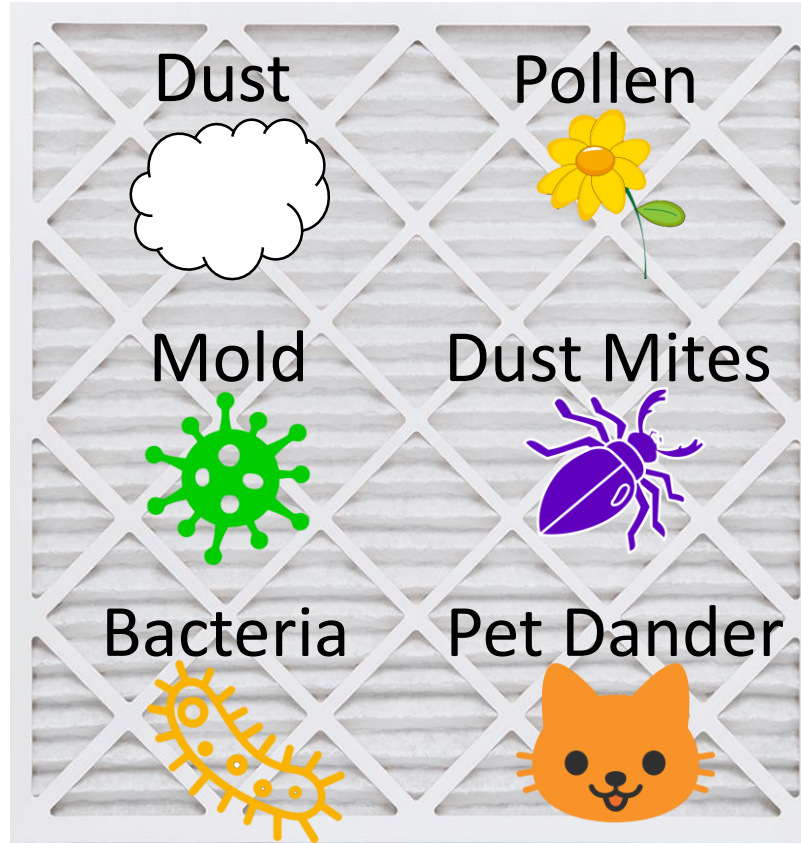


Joseph Thyer

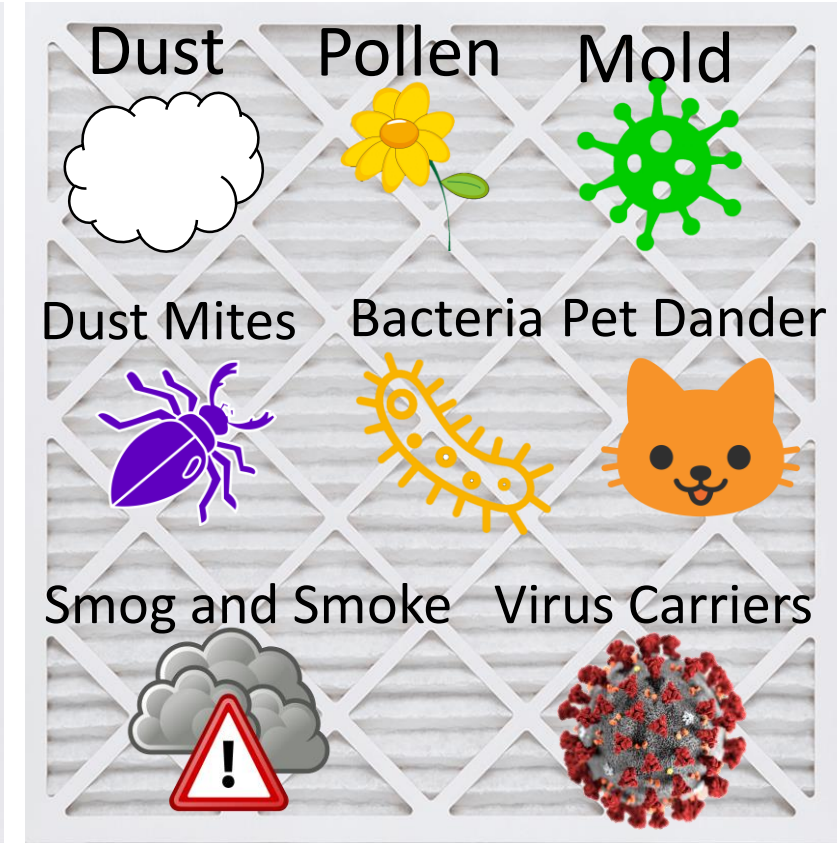
MERV 8



MERV 11

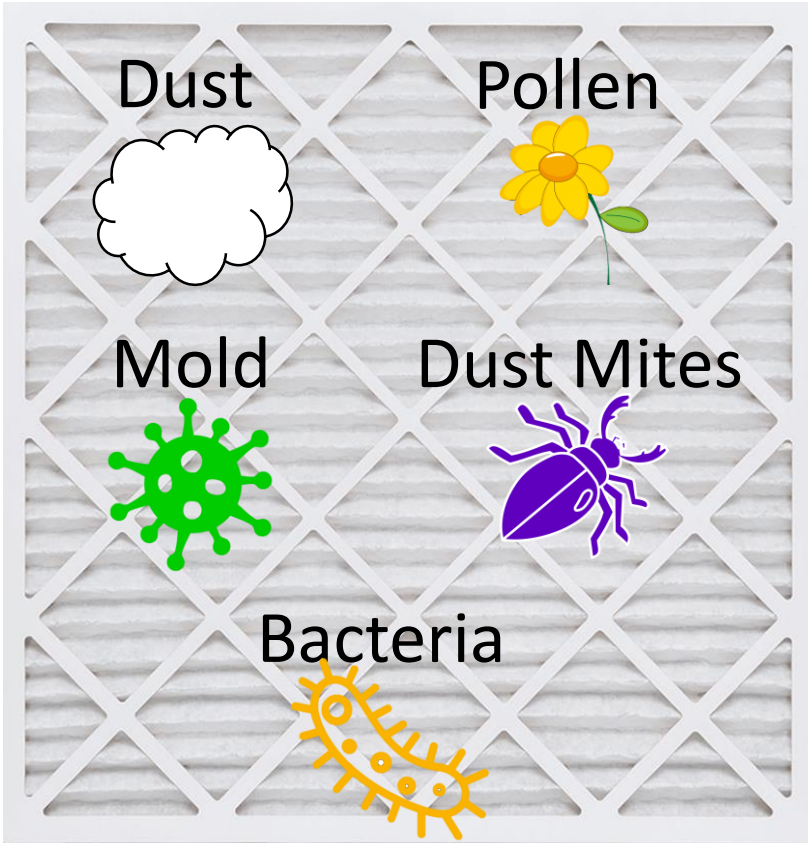


MERV 13

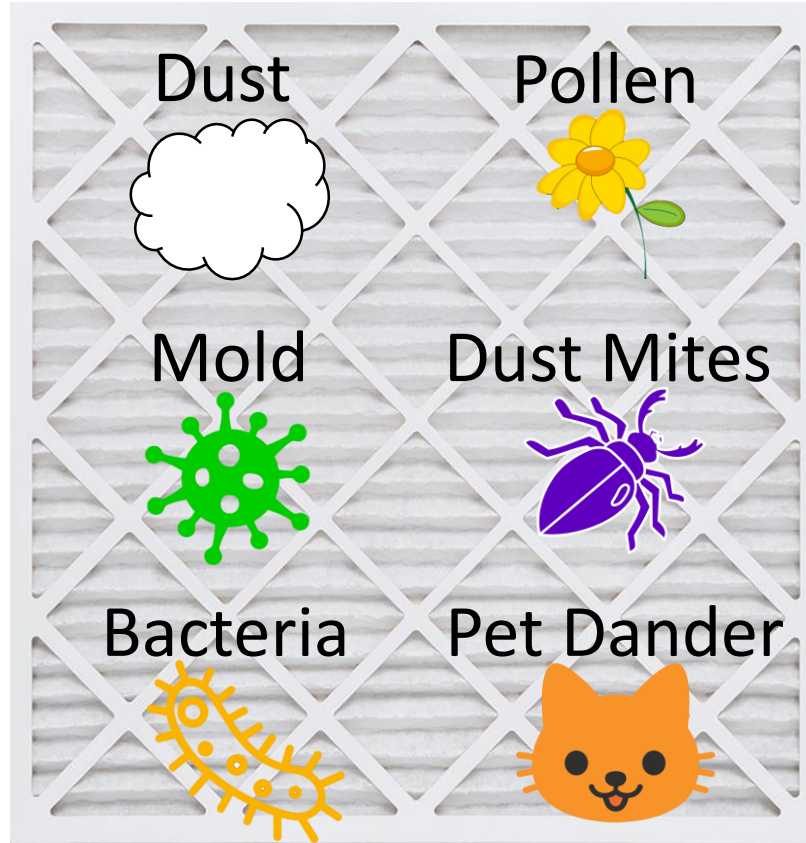


Joseph Thyer

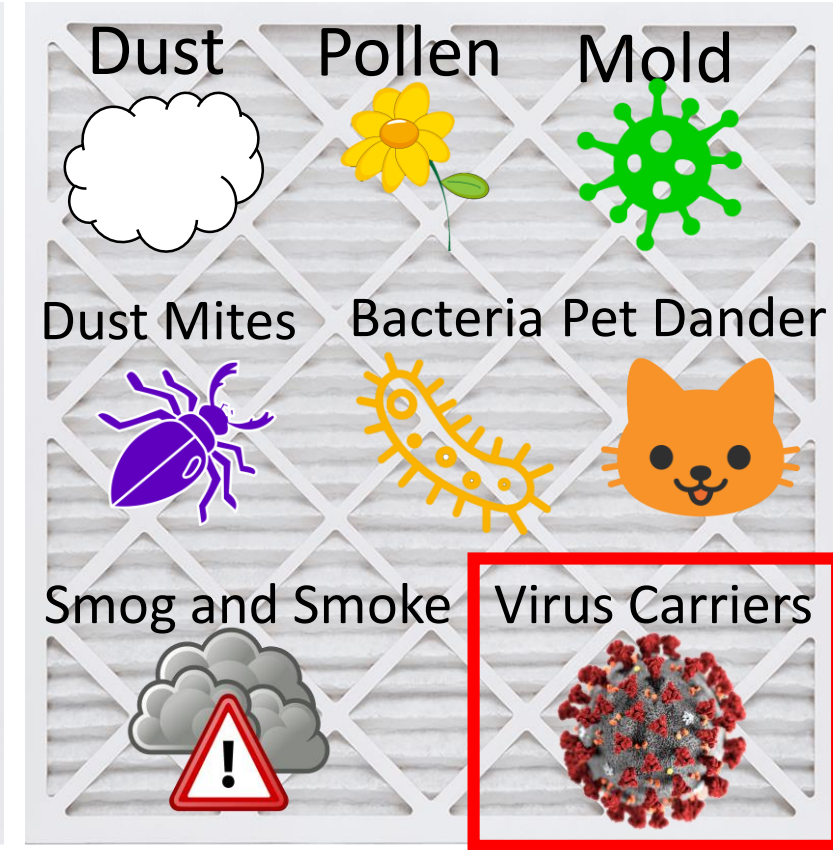
MERV 8



MERV 11



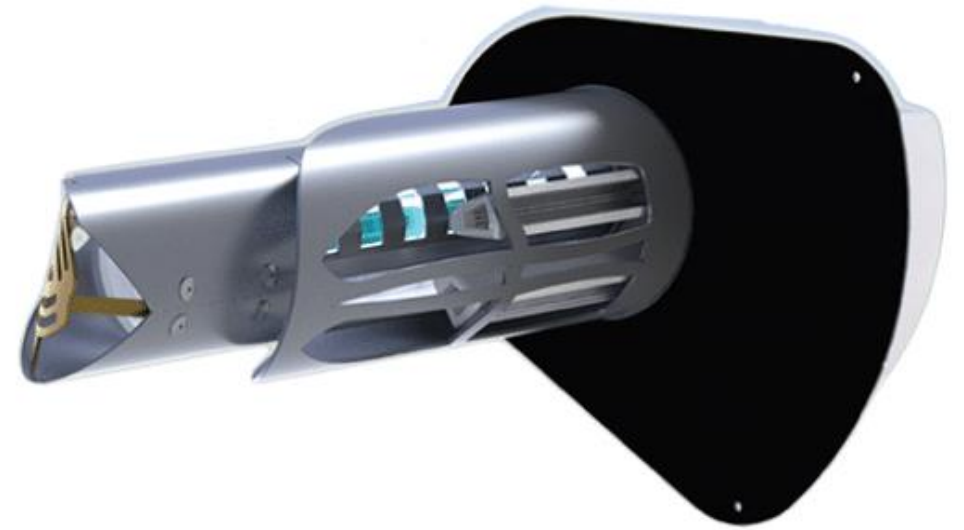
MERV 13



Joseph Thyer

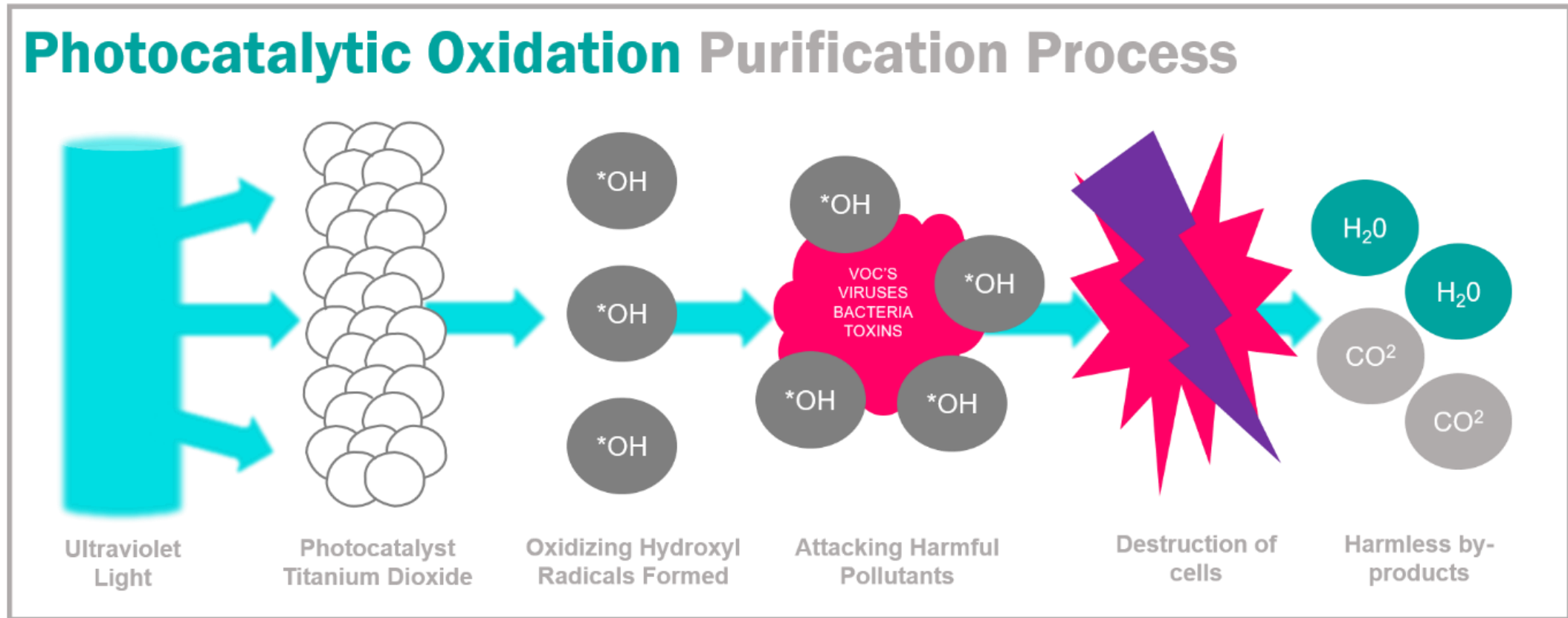
Photocatalytic Oxidation (PCO)

- Creates charged ions in the air that break down particles
- Photohydro Ionization (PHI) is similar to PCO but with a specific catalyst



Joseph Thyer

Photocatalytic Oxidation (PCO) cont.



Joseph Thyer

Dry Hydrogen Peroxide (DHP)

- Utilizes local humidity and oxygen to create hydrogen peroxide gas
- Dangerous in high concentrations
- The gas becomes ionized and attaches to particles

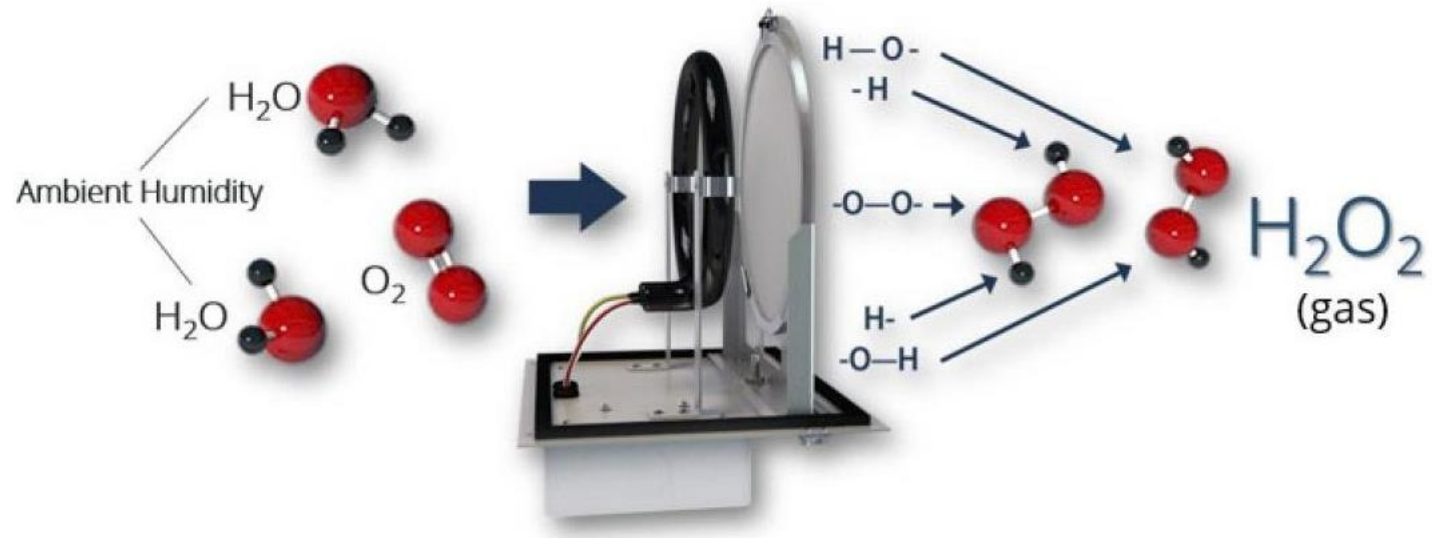
Joseph Thyer

Dry Hydrogen Peroxide (DHP) cont.

- Can be fitted into the existing systems duct work
- Effective against:
 - Fungal spores
 - Bacteria
 - Viruses

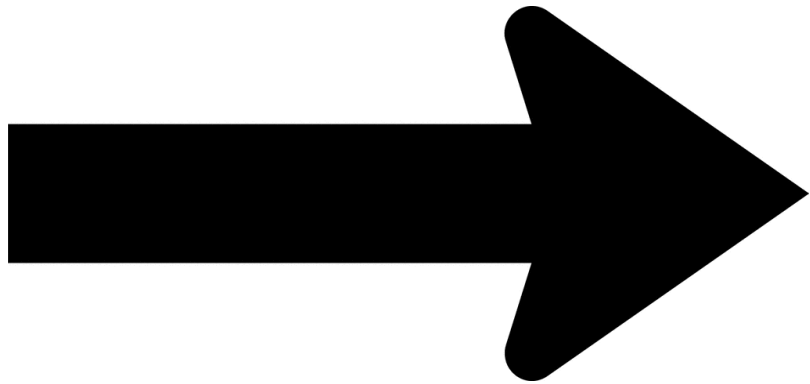
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Dry Hydrogen Peroxide (DHP) cont.



Joseph Thyer

Moving Forward



- Over the next few weeks
 - Meet with Marcela Castaño
 - Produce bill of materials
 - Develop Spring gameplan

Joseph Thyer

Conclusion

1. We need to improve air quality in a way that affects COVID but is useful independent of COVID.
2. There are lots of possible promising solutions.
3. Particle Ionization is the selected concept.



Joseph Thyer

Questions?



Reference

Air Quality. (2019, December 24). Retrieved October 15, 2020, from <https://morpc.gohio.com/commute-resources/air-quality/>

Corson, S., & Vargas, M. (2020, August 19). TRANE: Indoor Air Quality (IAQ)- Related HVAC Guidance from ASHRAE® and the CDC. Retrieved October 13, 2020.

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Image Library. (2020, February 10). Retrieved October 15, 2020, from <https://www.cdc.gov/media/subtopic/images.htm>

Reference cont.

Lower, A. (2020, November). **Will a higher MERV filter affect my airflow?** Retrieved November 10, 2020, from <https://www.secondnature.com/blog/higher-merv-air-filter-affect-air-flow>

Marsden, J., & Fink, R. (2020, May). **Hydro-Peroxide for Indoor Air Quality.** Retrieved November 10, 2020, from <https://www.rgf.com/article/hydro-peroxide-for-iaq/>

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Man in face mask. (n.d.). Retrieved October 14, 2020, from <https://www.vectorstock.com/royalty-free-vector/man-in-face-mask-line-icon-pictogram-disease-vector-31740115>

Additional Slides



Customer Needs Process

Customer Statement

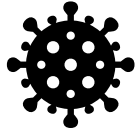
- Indoor air quality is not sufficient enough to diminish the threat of harmful viruses
- Trane is driven to provide the lowest life cycle cost, efficient energy usage to reduce carbon emissions, and for sustainability in future markets

Interpreted Need

- The solution must **improve air quality**
- The solution must be **cost-effective** and be **sustainable**

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Pollutant Categories



Biological

- Bacteria
- Viruses
- Fungi
- Dust Mites
- Animal Dander
- Pollen



Chemical

- Accidental chemical spills
- Cleaning Supplies
- Paints & Adhesives
- Products of combustion (CO, H₂CO, NO₂)

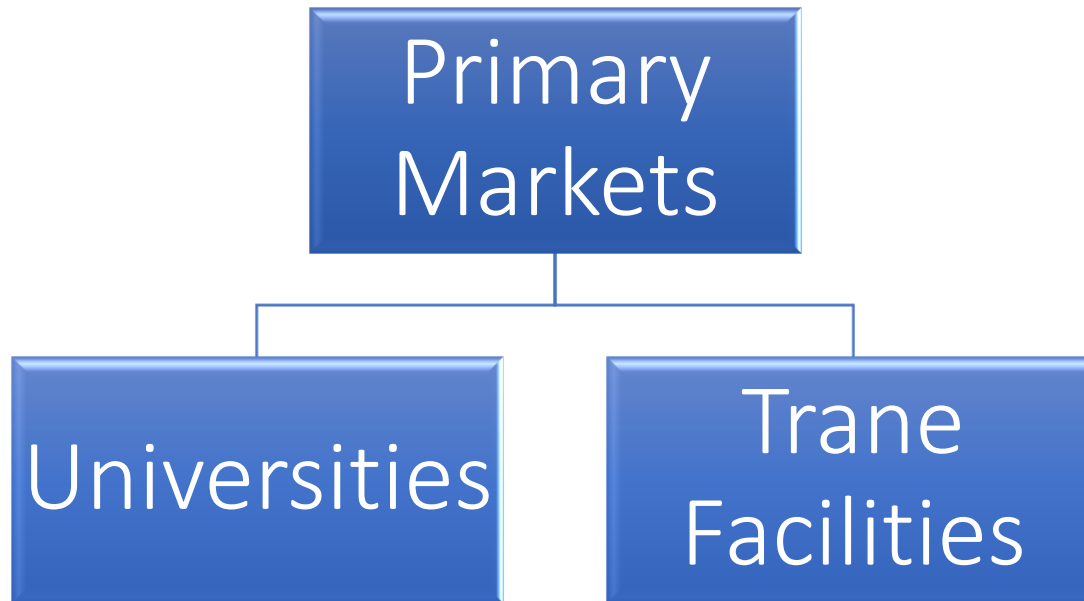


Particle

- Dust
- Dirt

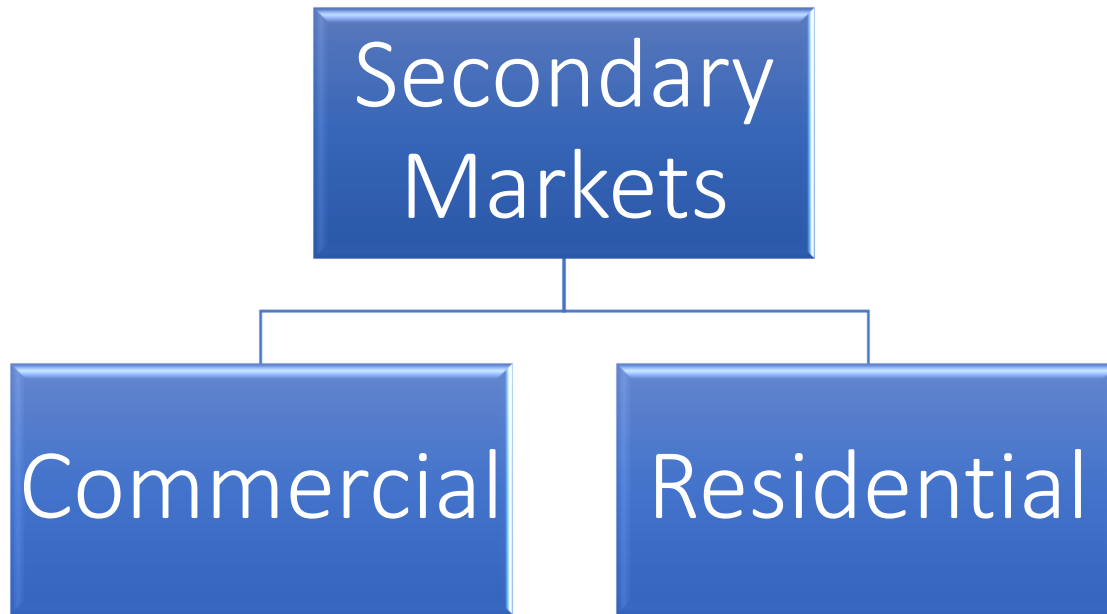
Andreu Santeiro

Primary Markets



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Secondary Markets



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Project Scope



Andreu Santeiro

Assumptions

- Existing infrastructure
- Government & environmental guidelines
- Market specific guidelines/budget
- Testing done in Florida climate



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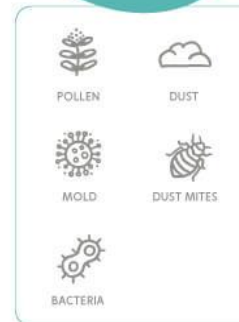
Higher Quality Filters

- Not universal solution
- Temporary
- Easiest installation*

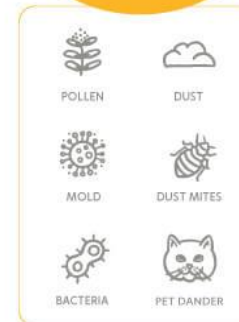
Filter Ratings Explained

MERV • MPR • FPR

Catch Some
MERV 8
Compares to
MPR 600
FPR 5



Catch More
MERV 11
Compares to
MPR 1000-1200
FPR 7



Catch All*
MERV 13
Compares to
MPR 1500-1900
FPR 10



PCO

- **How Photocatalytic Oxidation Purifies the Air**

- Photocatalytic oxidation is achieved when you combine UV rays with a TiO₂-coated filter. TiO₂ refers to Titanium Oxide. This process creates hydroxyl radicals and super-oxide ions, which are highly reactive electrons.
- These highly reactive electrons aggressively combine with other elements in the air, such as bacteria and VOCs. VOC is an acronym for Volatile Organic Compounds, which include harmful pollutants such as formaldehyde, ammonia and many other common contaminants released by building materials and household cleaners generally found in the home.
- Once bound together, the chemical reaction takes place between the super-charged ion and the pollutant, effectively "oxidizing" (or burning) the pollutant. This breaks the pollutant down into harmless carbon dioxide and water molecules, making the air more purified.

- **Photocatalytic Oxidation Studies**

- **Chemistry scientists** from the **University of Colorado** and the **National Renewable Energy Laboratory** in Colorado conducted an experiment testing the effectiveness of photocatalytic oxidation against harmful VOCs (volatile organic compounds such as formaldehyde and other known carcinogens). They found that **destruction** of these contaminants was **nearly 100%**.
- Scientists working on behalf of the **U.S. Department of Energy** found that photocatalytic oxidation air purification may be beneficial for the large-scale treatment of air in occupied buildings, while conserving energy costs. This is due to the fact that this technology **destroyed VOC chemicals** at a significant rate, even at high air flow rates. Their study indicated that photocatalytic oxidation could provide as much VOC removal by itself as compared to the expensive process of introducing outdoor air into the indoor environment, drastically reducing the need to channel outdoor air inside.
- In another study commissioned by the **U.S. Department of Energy**, scientists found that photocatalytic oxidation converted **more than 95%** of harmful VOC chemicals to harmless carbon dioxide and water molecules.

PHI

- **Photohydroionization® (PHI)** is an advanced oxidation technology developed by RGF Environmental Group to minimize and neutralize indoor air pollutants such as bacteria, viruses, mold, gases (VOCs) and odors.

PHI utilizes a broad-spectrum, high intensity UV light targeted on a hydrated quad-metallic catalyst surface. This target surface is covered with a proprietary quad-metallic and hydrophilic coating. The UV light reacts with the catalyst and moisture to produce an advanced oxidation plasma consisting of hydro-peroxides, super oxide ions and hydroxide ions. These friendly oxidizers will revert back to oxygen and hydrogen once they've come in contact with and eliminated the pollutant.

Bipolar Ionization & NPBI

- <https://alphamechanicalservice.com/serviceareas/kentucky/louisville/bipolar-ionization-technology/>
- NPBI
- <https://www.midwestmedicaledition.com/2020/07/09/320800/needlepoint-bipolar-ionization-system-from-hvac-elements-provides-protection-from-sars-cov-2-and-more>
- Global Plasma Solutions has a cost effective, easy to install solution that achieves these goals without excessive long term costs or maintenance. By utilizing Needlepoint Bipolar Ionization, GPS units generate a high voltage field that creates positive and negative ions. These ions travel through the airstream and actively target contaminants in the air field, strips them of hydrogen and reduces them to harmless base compounds.

Functional Decomposition cont.

- Promote Sustainability
 - Minimize operating costs
 - Improve system longevity
 - Optimize energy-efficiency
 - Fit existing HVAC systems

Jake Hamilton



Pairwise Comparison

Binary Pairwise Comparison						
	1	2	3	4	5	Total
1. Air Quality	-	1	1	1	1	4
2. Longevity	0	-	0	1	0	1
3. Energy Efficiency	0	1	-	1	0	2
4. Total Cost	0	0	0	-	1	1
5. Retrofit	0	1	1	0	-	2
Total	0	3	2	4	1	10



House of Quality

House of Quality						
Engineering Characteristics						
Improvement Direction		↓	↓	↑	↓	↓
Units		kg	kW	m ³ /s	ppm	USD
Customer Requirements	Importance Weight Factor	Mass	Energy Consumption	Flow Rate	Contaminant Concentration	Installation cost
1. Air Quality	4		3	9	9	
2. Longevity	1			9	9	
3. Energy Efficiency	2		9	3		
4. Total Cost	1					9
5. Retrofit	2	3				9
Raw Score	159	6	30	51	45	27
Relative Weight %		0.038	0.189	0.321	0.283	0.170
Rank Order		5	3	1	2	4

Pugh Chart

Pugh Matrix - 1									
		Concepts							
Engineering Characteristics		1	2	3	4	5	6	7	8
Mass	Datum	+	+	+	+	+	-	S	+
Energy Consumption		+	+	+	-	+	+	+	+
Flow Rate		-	-	-	+	-	+	-	-
Contaminant Concentration		+	+	+	+	+	+	+	+
Installation cost		+	-	-	+	+	-	+	+
# of pluses		4	3	3	4	4	3	3	4
# of minuses		1	2	2	1	1	2	1	1

Legend

-  Selected Concept
-  New Datum

Pugh Chart continued

Pugh Matrix - 2					
		Concepts			
Engineering Characteristics		1	4	5	8
Mass	Datum Concept 2	+	+	+	+
Energy Consumption		+	-	+	+
Flow Rate		-	+	+	+
Contaminant Concentration		+	+	+	+
Installation cost		+	+	-	+
# of pluses		4	4	4	5
# of minuses		1	1	1	0

Dry Hydrogen Peroxide

- https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=507840
- http://apicnyc.org/uploads/3/4/0/6/34063157/presentation_-_michelle_vignari_-_dry_h2o2_-_nov_20_2018_web_copy.pdf

Functional Decomposition cont.

- Control System
 - Maintain recommended humidity levels
 - Maintain recommended CO2 levels
 - Maintain comfortable temperature
 - Monitor VOC concentration



Jake Hamilton