

INCREASE YOUR

H₂IQ

The #H2IQ Hour

Today's Topic:

Leveraging Hydrogen and Fuel Cell Tech to Help
Coronavirus Relief Efforts

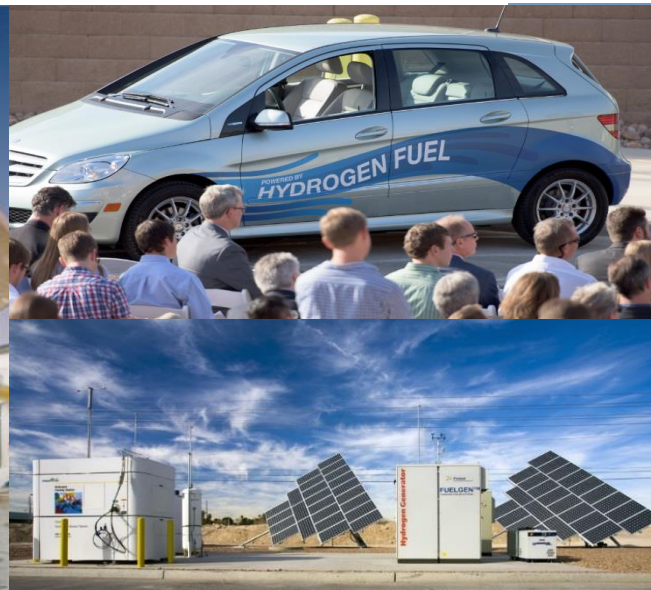
This presentation is part of the monthly H2IQ hour to highlight research and development activities funded by U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

Hydrogen and Fuel Cell Technologies Office Introduction

Vanessa Arjona

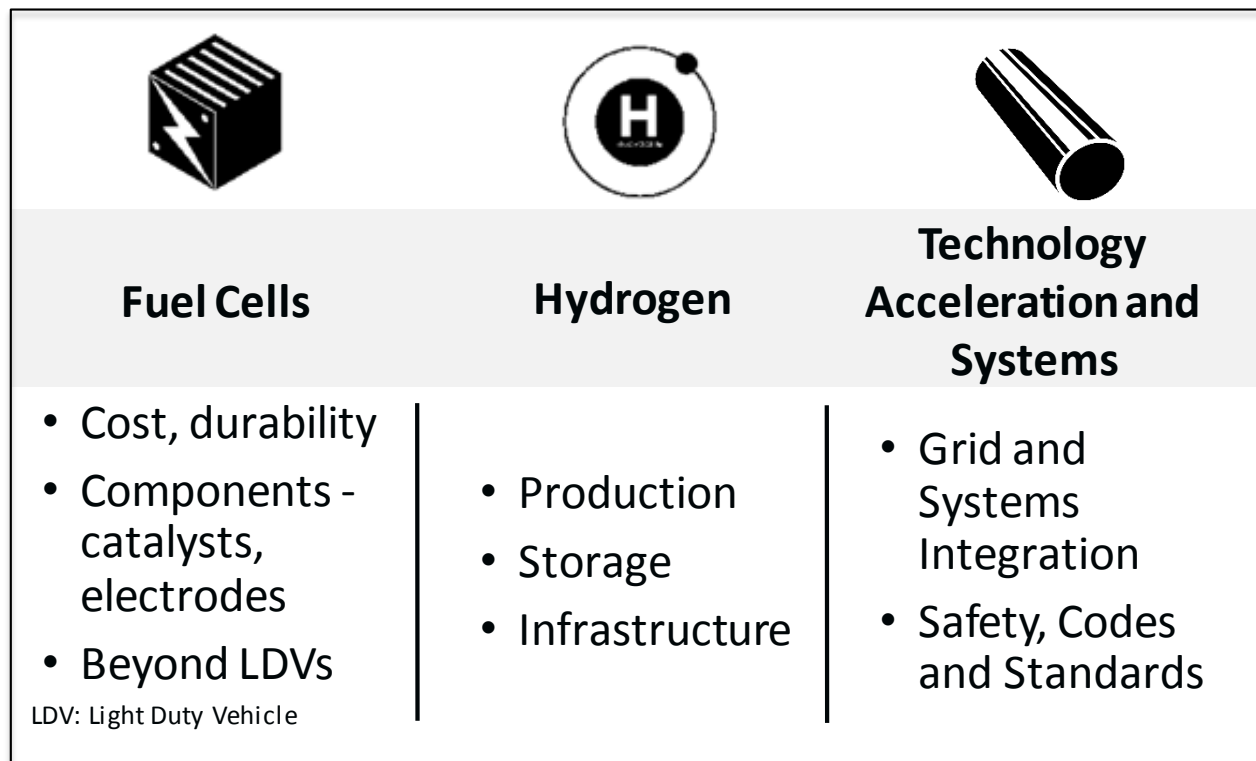
H2IQ Hour- Leveraging Hydrogen and Fuel Cell Tech to Help Coronavirus Relief Efforts

May 27, 2020

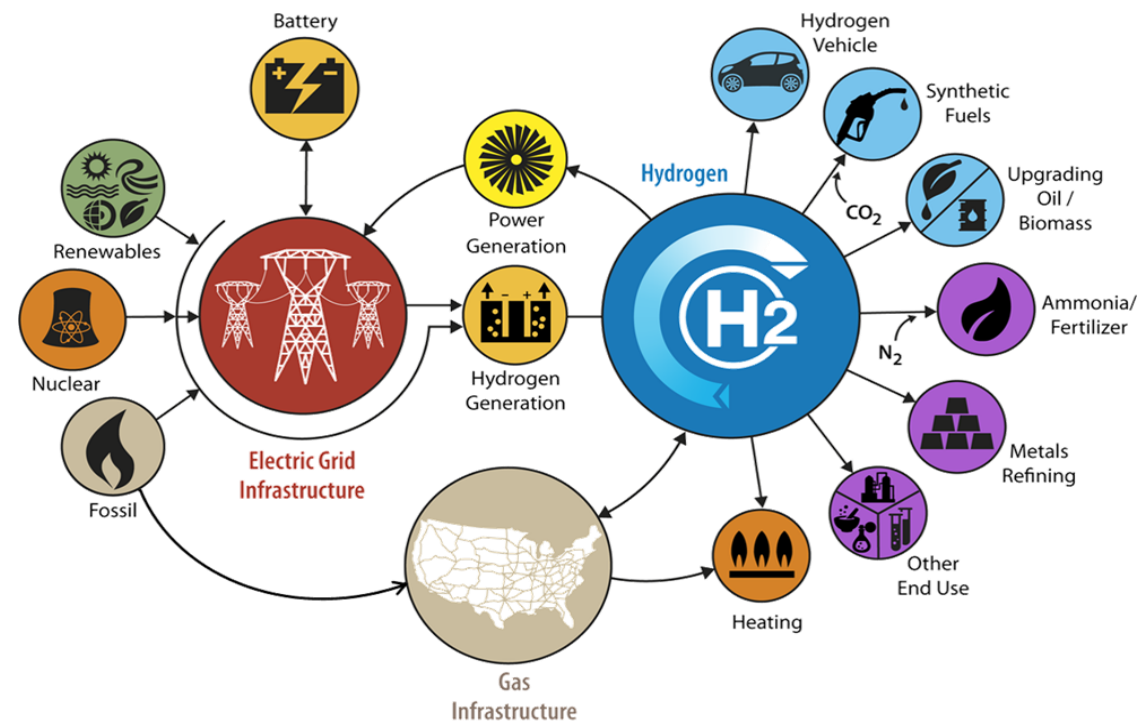


The Hydrogen and Fuel Cell Technologies Office (HFTO)

Examples of Research and Development Areas



H2@Scale Vision



Universities

National Labs

Industry

States


Investors

International

Collaboration and Coordination with HFTO Stakeholders Helps to Drive Progress

From R&D to Proven Technologies in Real World - Examples

Innovation



960

patents


enabled by HFTO funds

Approx.

37%

of H₂ and fuel cell patents come from National Labs

Market Impact



More than

30

Technologies commercialized by private industry

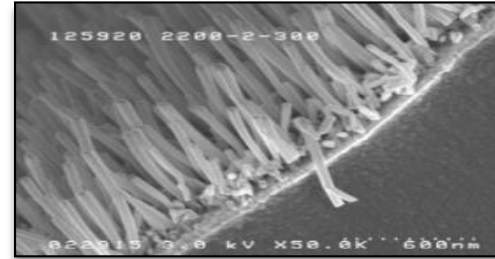
and over

65

with potential to be commercial in the next 3-5 years

can be traced back to HFTO R&D

Fuel Cell Catalysts



Catalyst and Supports for PEM Fuel Cells – 3M

Electrolyzers



Proton's Series Electrolyzer System



Giner's PEM Electrolyzer System

Hydrogen Tube Trailers



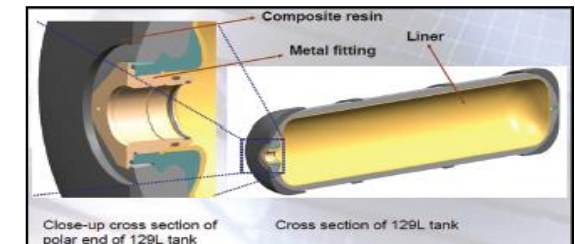
Hydrogen Tube Trailers – Hexagon Lincoln

Forklifts



Class-1, -2, and -3 Forklifts Powered by Plug Power's GenDrive FCs

Hydrogen Tanks



Quantum Technologies' Optimized 129L Tank

Using R&D and Technology To Make a Difference During COVID-19

Bloom Energy, CA and DE

- Refurbished ventilators for use in hospitals.

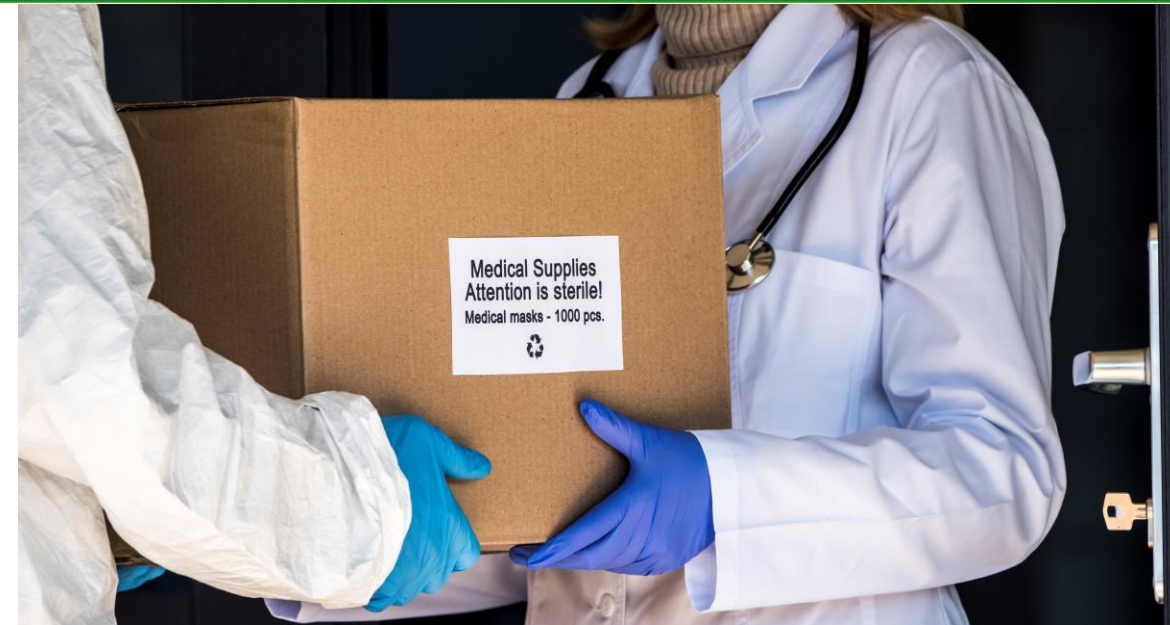
Doosan Fuel Cells America, CT

- Donated PPE including nitrile gloves, face shields, lab coats and aprons to local healthcare providers

Hexagon, NE

- Donated server capacity to conduct COVID-19 research and respiratory masks to hospitals in Germany.

Source: Fuel Cell and Hydrogen Energy Association



Using R&D and Technology To Make a Difference During COVID-19



Oak Ridge National Lab (ORNL), TN

- Used their carbon fiber technology facility to develop input materials to produce N95 masks.

PDC Machines, PA

- Donated masks to healthcare providers.

Plug Power, NY

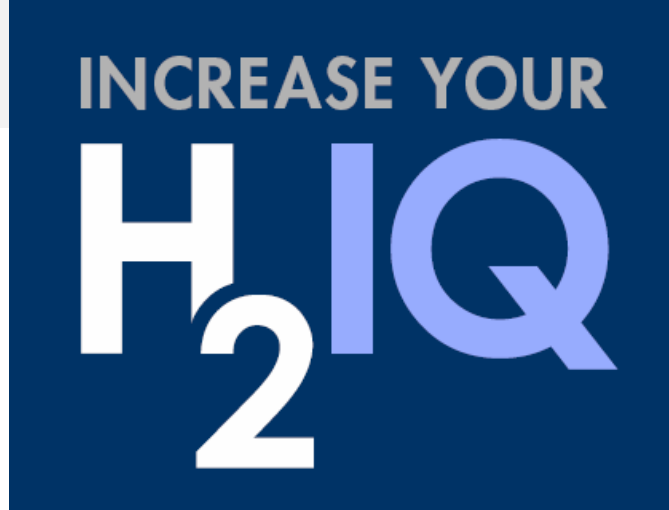
- Provided H2 fuel cell forklifts to help transport food at supermarkets and other major retailers.

Power Innovations, UT

- Leveraged expertise in technology for military applications to produce ventilator parts and masks.

Source: Fuel Cell and Hydrogen Energy Association





The #H2IQ Hour

Air Co. and NEL

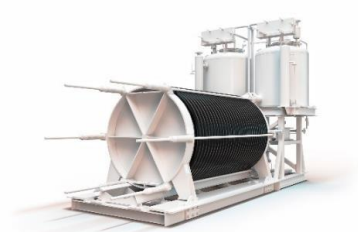
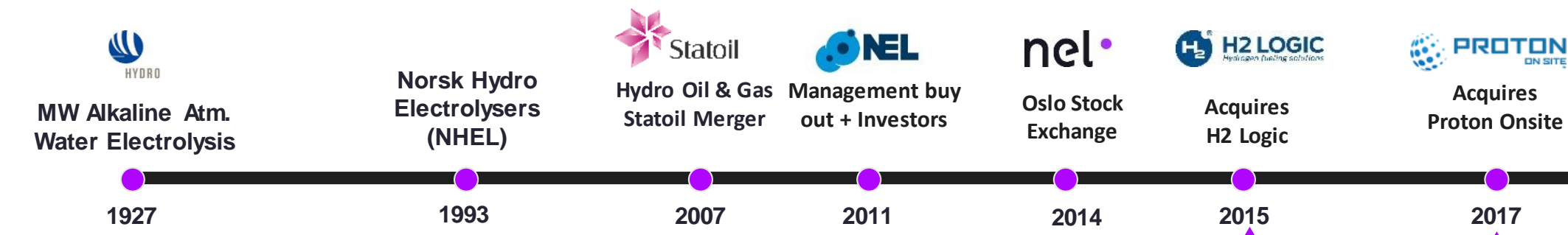
Renewable Hydrogen to Enable Green Chemical Production

Dr. Kathy Ayers, Vice President, Research and Development

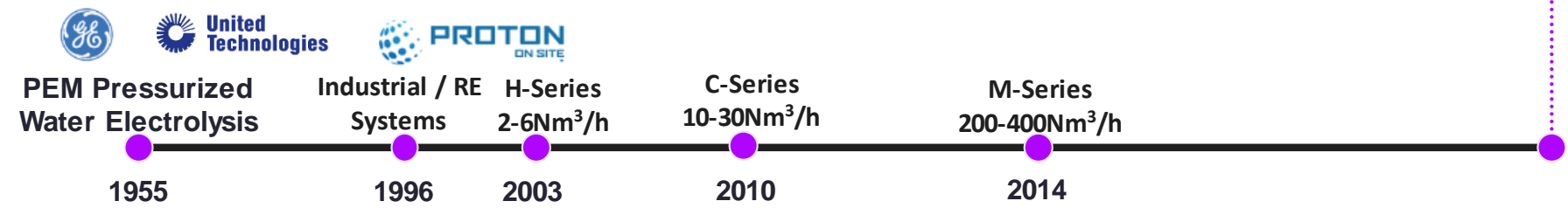
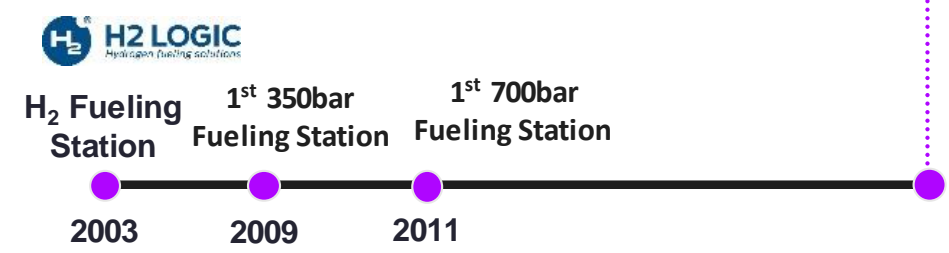


nel 
number one by nature™

Nel Hydrogen company history



3 Manufacturing Sites
3,500+ Electrolyzers Installed
40+ H₂ Fueling Stations
90+ Years Experience



Hydrogen From Proton Exchange Membrane Electrolysis

- Originally used for **life support** (O₂) in closed environments: Optimized for **very high reliability**
- Commercializing at increasing scale
- Decreasing cost and improving efficiency through component advancement and scale up

CONVENTIONAL INDUSTRY



Food Industry



Glass Industry



Polysilicon Industry



Laboratories



Chemical Industry



Thermal processing



Chemical vapor deposition



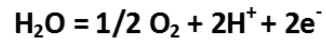
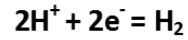
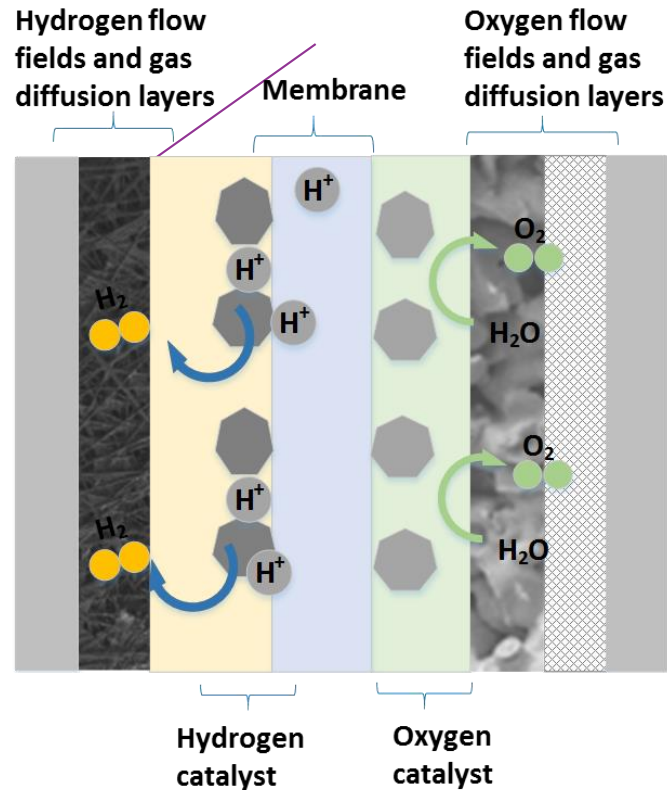
Steel Industry



Power Industry

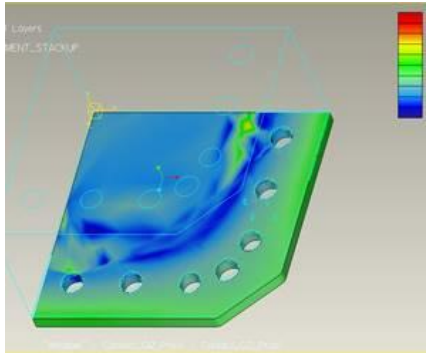


Life Support

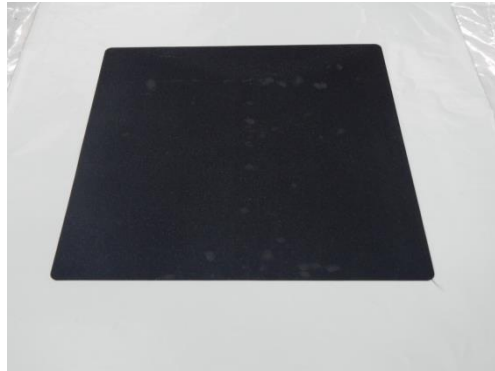


- Conventional industries represents “traditional” hydrogen markets
- Steady demand for hydrogen

Fundamental R&D to Prototyping



Component modeling



Electrode manufacturing



Accelerated embrittlement

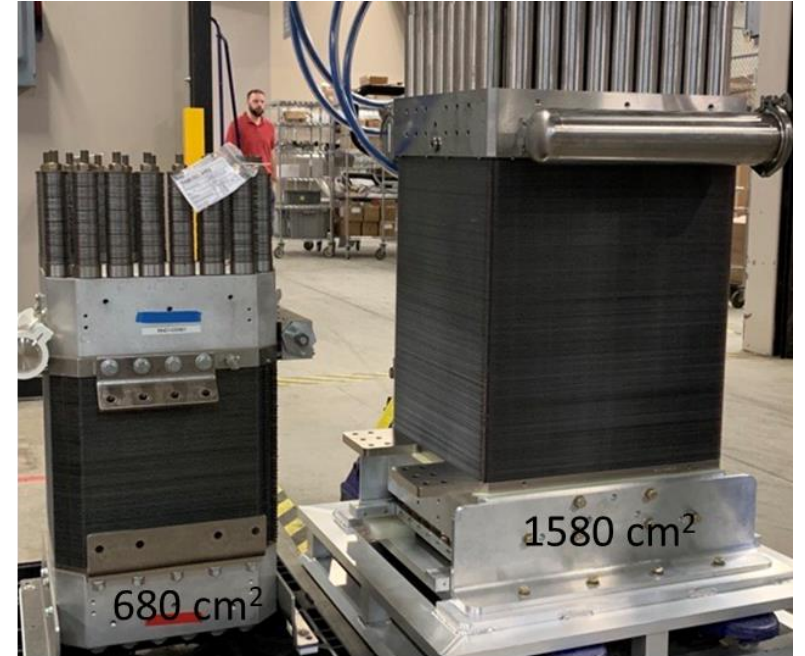


Materials and manufacturing research

Products from kW to MW scale



90 cm²



680 cm²

1580 cm²

Nel scale up and commercialization: 1.25 MW stack based on same platform

AIR
C·O

Almost Impossible

AIR
C·O

AIR COMPANY

THE WORLD'S FIRST
CARBON-NEGATIVE
ALCOHOL COMPANY

THE PROBLEM

**THE GLOBAL ALCOHOL INDUSTRY IS
NOT ENVIRONMENTALLY FRIENDLY.**

OUR SOLUTION

**TO TRANSFORM THE INDUSTRY WITH THE
HIGHEST QUALITY
MOST SUSTAINABLE PRODUCTS,
THAT HELP NOT HURT OUR PLANET.**

OUR PROCESS

STEP 01



Air

Powered by local renewable energy sources, carbon dioxide (CO₂) is captured from air or point source.

STEP 02



Water

Water is split into O₂ and H₂. The H₂ is combined with CO₂ and exposed to our catalysts.

AIR
C.O

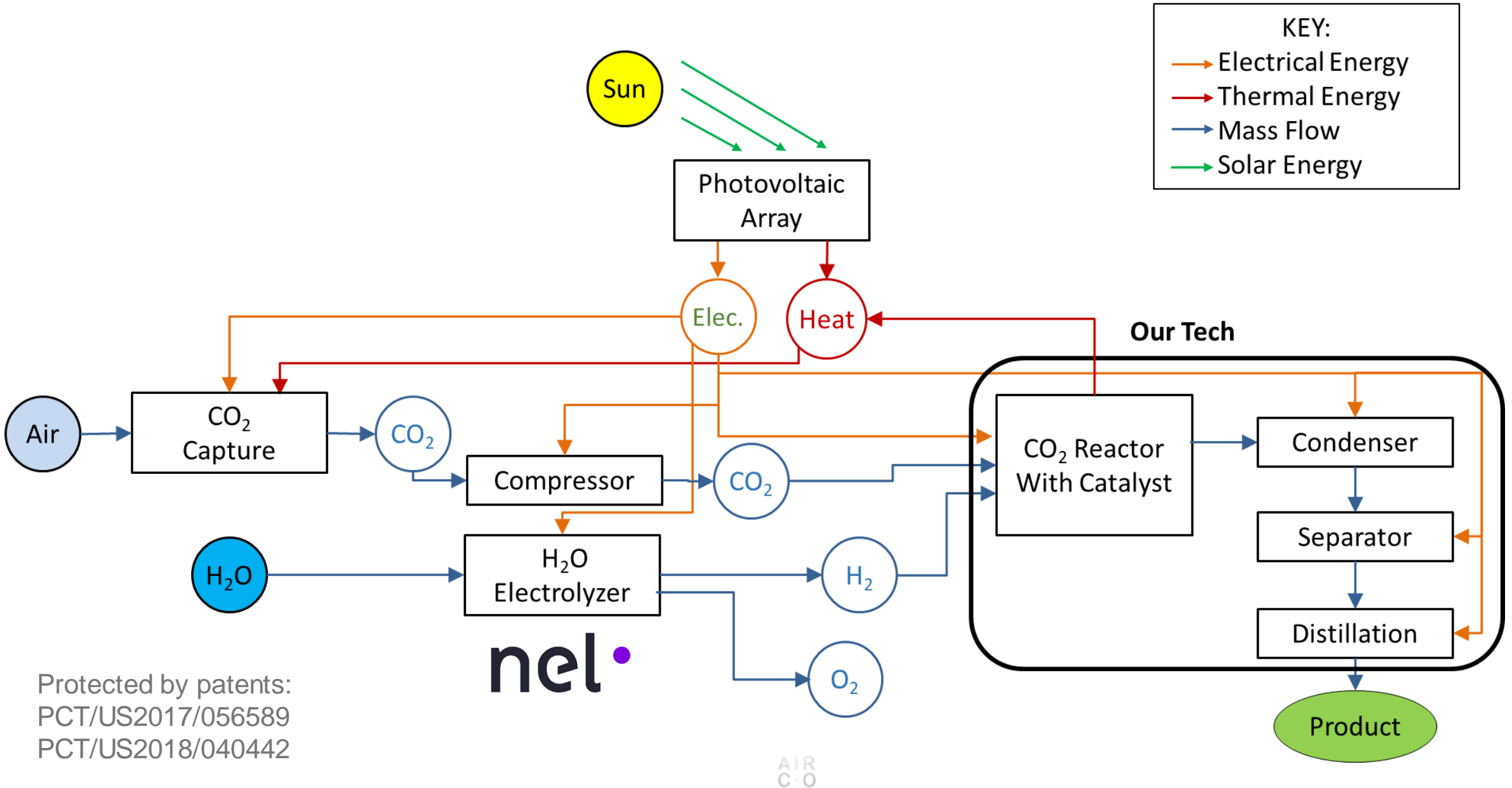
STEP 03



Ethanol

Solar electricity powers the process, creating alcohol.

OUR APPROACH



Protected by patents:
PCT/US2017/056589
PCT/US2018/040442

OUR APPROACH



OUR VODKA



GOLD MEDALS IN TWO INTERNATIONAL SPIRITS COMPETITIONS - BLIND TASTE TESTS

OUR SANITIZER (COVID-19 RESPONSE)

YD
YANKO DESIGN

YOUR HAND SANITIZER MAY HAVE 60% ALCOHOL BUT IS IT CARBON NEGATIVE?

BY RUCHI THUKRAL / 03/18/2020



I have never really paid attention to the ingredients of a hand sanitizer before the pandemic which taught me that the Bodyworks glitter ones really won't help and I have to look for ones that have 60% alcohol or above. Obviously, the AIs of the worldwide web picked up on my searches and I 'came across' the world's first carbon-negative hand sanitizer made by New York-based startup, Air Co. I am all about sustainable living and a carbon-negative sanitizer was exactly what I needed to replace the glitter.

The pandemic caused an exponential increase in the demand for sanitizers, and in a bid to help health

FASTCOMPANY

This carbon-negative hand sanitizer is made from captured CO2

Across the country, many distilleries are switching from making booze to making sanitizer. Air Co.'s carbon-neutral vodka factory is doing the same.



BY ADELE PETERS
1 MINUTE READ

When it launched last year, the New York City-based startup Air Co. made the world's first carbon-negative vodka—using captured CO2 instead of yeast to make alcohol. Now, in response to the coronavirus crisis, it's using that same captured CO2 to make hand sanitizer instead.



YAHOO!
FINANCE

CO2-based vodka startup Air Co. fully redirects its tech to making hand sanitizer for donation

TC **Darrell Etherington**
TechCrunch March 17, 2020

A NYC-based startup that developed technology that extracts carbon dioxide from the air and combines it with water to create vodka has redirected its entire production capacity toward producing hand sanitizer, every bottle of which will be donated through collaboration with NYC officials, and potentially to local restaurants who employ delivery personnel providing critical service as social distancing and isolation measures continue.

Air Co. launched its vodka just last year, using a process it developed (which has received awards from NASA and XPrize) that is actually net carbon-negative. It involves pulling around one pound of carbon dioxide from the air which is then combined with water and turned into pure ethanol using solar-based renewable energy. Ethanol also happens to be the key active ingredient in hand sanitizer, which is generally between 60% and 95% alcohol in its most effective iterations.

Air Co.'s CEO and co-founder Gregory Constantine told me via email that because the company was founded on the basis of fulfilling a mission of social good, the startup wanted to find some way to help with community efforts to counter the ongoing coronavirus pandemic. It naturally turned to producing hand sanitizer made up 70% ethanol, its technology's primary output.

The company isn't looking to cash in on the current (ill-advised) panic-buying trends, which see supplies of hand sanitizer sold out or dwindling across major retailers and Amazon. Instead, even though it's now directing 100% of its production capacity to

TC TechCrunch

CO2-based vodka startup Air Co. fully redirects its tech to making hand sanitizer for donation



A NYC-based startup that developed technology that extracts carbon dioxide from the air and combines it with water to create vodka has redirected its entire production capacity toward producing hand sanitizer, every bottle of which will be donated through

Inc.

STRATEGY New York City Needs More Hand Sanitizer. This Award-Winning Vodka Startup's Response Is a Remarkable Act of Selflessness and Caring

Why Air Co. has totally shifted its net zero carbon footprint manufacturing process to make and distribute free hand sanitizer for its NYC community.

in f t

By Jeff Haden Contributing editor, Inc. @jeff_haden



GETTY IMAGES

Many entrepreneurs start companies with a larger social or environmental mission in mind.

Like Air Co., the vodka startup co-founded by Gregory Constantine and Stafford Sheehan that instead of using yeast take carbon dioxide produced by nearby factories, combine it with water, and use solar-based renewable energy to create ethanol.

According to Sheehan, the process is "inspired by photosynthesis in nature, where plants breathe in CO2. They take up water, and they use energy in the form of sunlight to make things like sugars and to make other higher-value hydrocarbons, with oxygen as the sole by-product.

AIR CO. SANITIZER

Donated sanitizer for healthcare workers at these and several other organizations:



**Mount
Sinai
Hospital**

Mount Sinai Hospital
New York, NY



The Brooklyn
Hospital Center

The Brooklyn Hospital Center
Brooklyn, NY



New York Police Department *via* Black 6 Project
Brooklyn, NY



**CAPE COD
HEALTHCARE**

Cape Cod Hospital
Hyannis, MA



Stratford EMS
Stratford, CT



Grady Memorial Hospital
Atlanta, GA



Portsmouth Naval Hospital
Portsmouth, VA



Vassar Brothers Medical Center
Poughkeepsie, NY



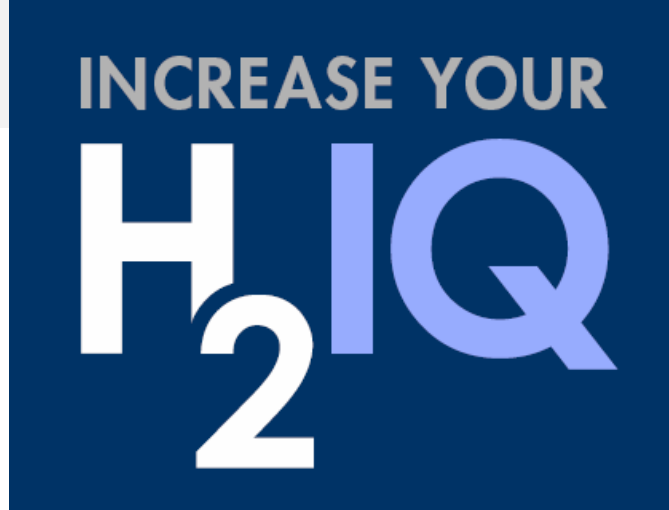
Custom Collaborative
Women's Organization
New York, NY



CONTACT FOR ADDITIONAL INFORMATION OR PURCHASING

DR. STAFFORD W. SHEEHAN
CO-FOUNDER & CTO
STAFF@AIRCOMPANY.COM

FOR COMPANY UPDATES:
www.instagram.com/aircompany



The #H2IQ Hour

e-Spin Technologies



Nanstructured PEM membrane to PPE products

eSpin Technologies, Inc.
7151 Discovery Drive
Chattanooga, TN 37416

May 27, 2020



Corporate Profile

- In Business for past 21 years
- Overall Sales: \$3.1MM (2019)
- # of Employees: 16 + Contract worker on need basis
- Products supplied: Air Filtration products, Wipes, membrane
- Global Customer Profile: US, German, and Japanese automotive plants and Tier 1 suppliers
- Manufacturing Footprint: Chattanooga, TN, USA

Key Technologies

- **Core Competency:** Nanofiber manufacturing
- **Key Processes:** Nanofiber production, nanoparticle integration and coating, thermal processing, lamination, slitting, die cutting, etc.
- **Key Products:** Air and Vent Filters, Wipes, Battery Separator, membrane (PBI, PVDF, TPU, PES), Face masks

Products being developed under DOE:

Ion exchange and BiPolar membrane, Pt. free PEM

The Opportunity

- COVID Pandemic: February 2020
- New customer request for Nanofiber media (Feb)
- Finishing up DOE SBIR Phase I to produce nanofiber membrane

Rapid Development

- Free up 24" wide machine (Early March)
- More demand predicted as COVID spreads
- 3 spinning machine dedicated by end of March
- Running 10 hr shift
- Modification of asset to make face mask
- Rapid prototyping of Pleating process
- Investment decision to purchase sonic bonding machine(s)



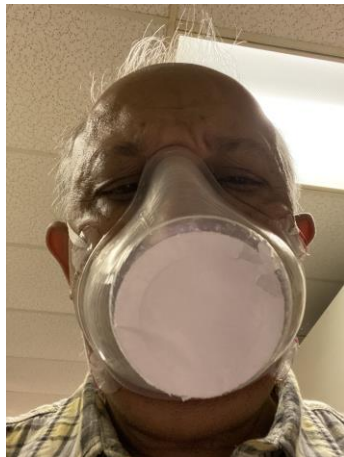
Increased manufacturing

- Increase mask production
 - Run 2 shifts
- Increase mask filter media production
 - Run 2 shifts of fiber spinning
 - Add 4th line to spinning
 - Hire/train contract workers
 - Assign shifts to eSpin team
- Safety became key
 - Increased solvent use
 - Solution preparation (@20 liters)
 - Movement of solution to spinning machine



Increased manufacturing

- Non-stop new calls (April)
 - City, Chamber, Local organizations
- More local people walk-in for nanofiber samples
- Develop fabric mask with pocket for Nanofiber
- Develop inserts for mold, thermoform



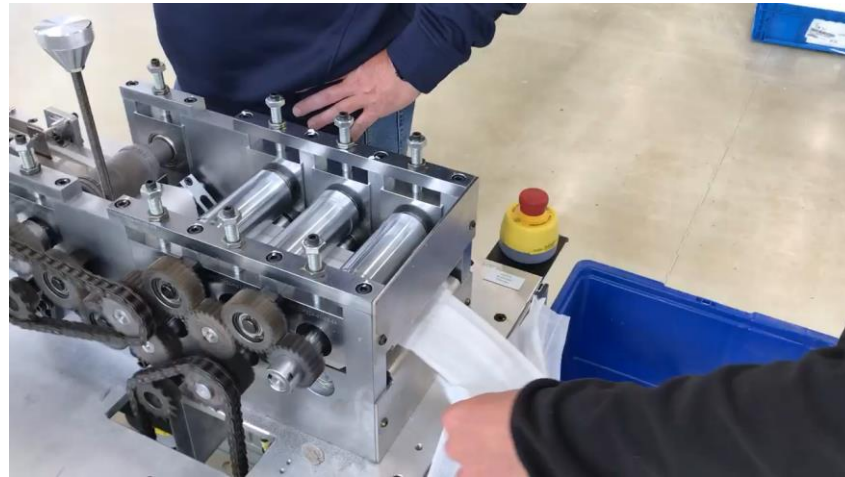
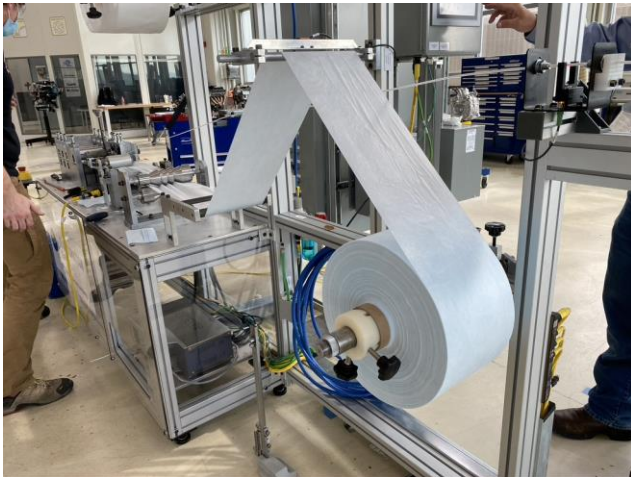
Increased manufacturing

- Form relationship with Whirlpool to make HEPA filter for powered air purifier respirator (PAPR)
 - Media Pleating
 - Selection of Adhesive
 - Frame development and rapid prototyping
 - NIOSH Test



Increased manufacturing

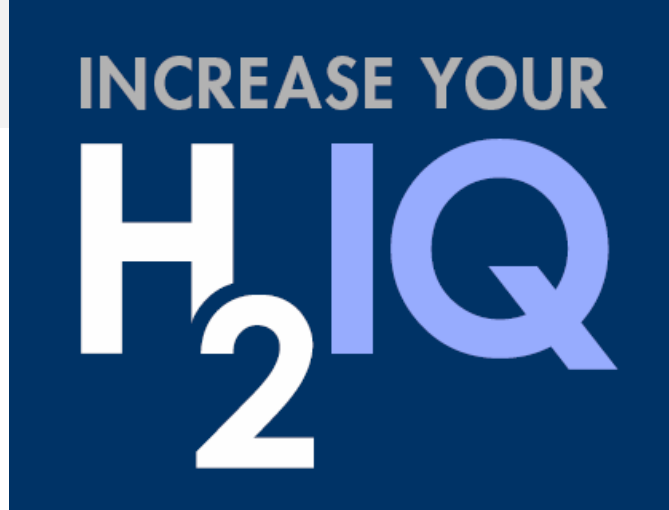
- Form relationship with Volkswagen to make surgical face masks
 - VW invests in mask machine
 - eSpin to provide 95% efficient masks
 - Production > 60,000 masks/day
 - Apply for NIOSH approval



Growth

- eSpin to increase work force
 - 20+ manufacturing
 - Run spinning machines 24/7
 - Produce 95% efficient face mask media
 - Other corporations
 - Internal use
 - Working with bank to build new spinning machine
 - Expand production capacity

Thank you



The #H2IQ Hour

Giner ELX



GINER ELX

Giner ELX Inc., 89 Rumford Ave, Newton, MA. 02466



Giner COVID-19 Engineering Efforts

Monjid Hamdan
VP of Engineering

H2IQ Webinar
May 27th, 2020

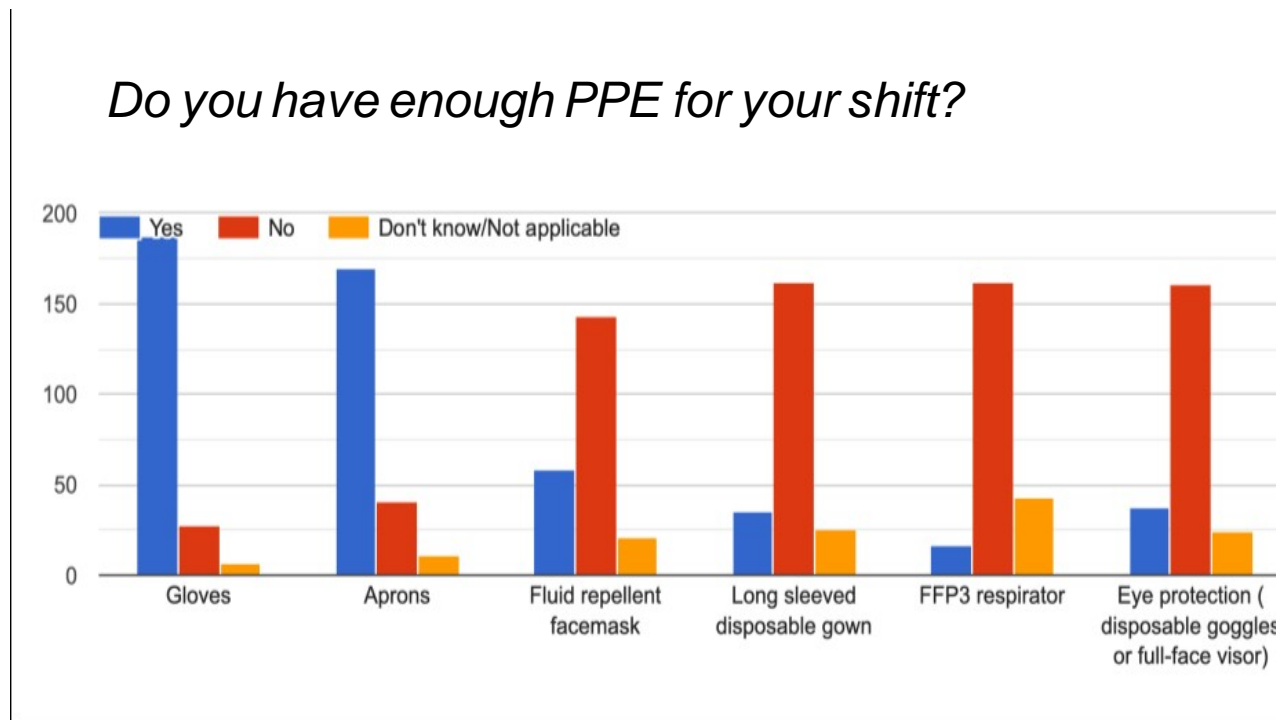
Introduction

- Hospitals across the country are facing unprecedented shortages of healthcare supplies needed to combat the novel coronavirus pandemic
- Giner, Inc. and its subsidiaries have stepped up to help meet these critical shortages by teaming with local hospitals
- Giner is fabricating surgical face masks and ventilator parts using equipment funded through DOE

Impact

- There is a global interest in ventilators and PPE as hospital are running low on supply
 - Off-label PPE and ventilator systems serve as bridge devices to help relieve supply shortages required to combat the covid-19 pandemic

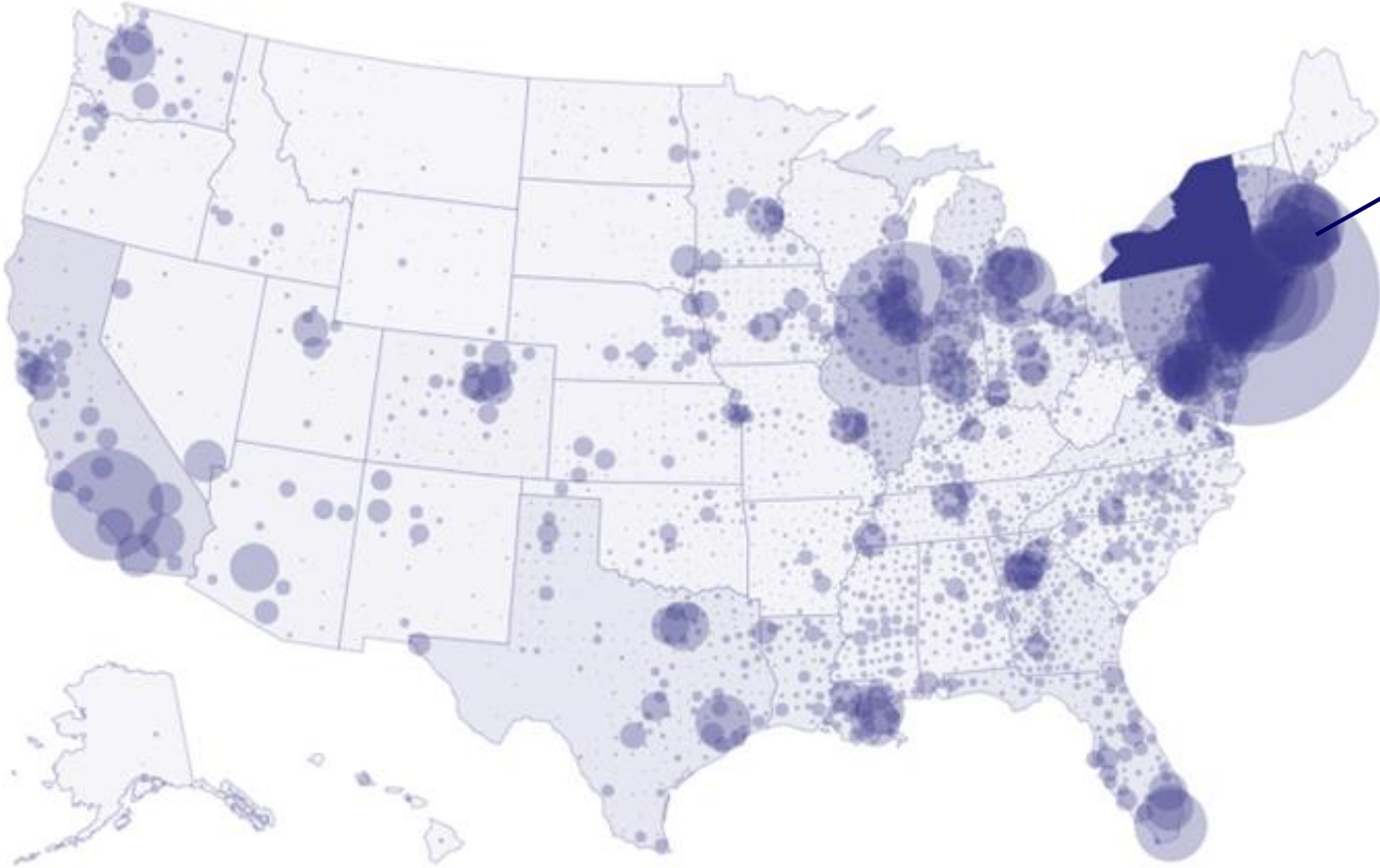
**Where can Giner help?
How fast can we respond?
Can we make a difference?**



Nurse poll hints at scale of shortage of key face masks, gowns, and respirators

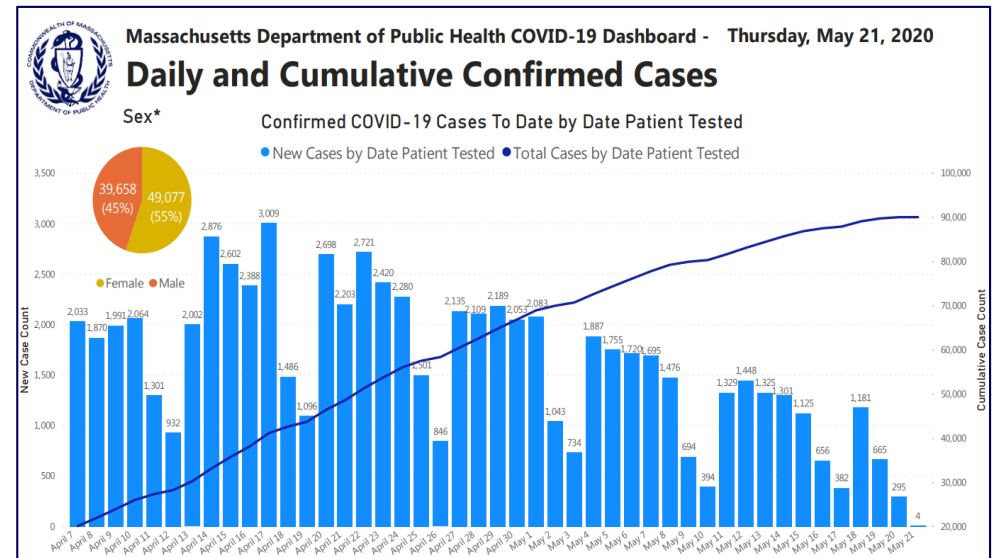
Source: Nursing Times / April 6th, 2020

Massachusetts Covid-19 Stats



TOTAL CASES*
90,084
NEW CASES*
1,114
DEATHS*
6,148

Source: John Hopkins University. May 15th, 2020



*Source: Mass.gov (May 21st, 2020)

Teaming with Mass General Brigham to provide rapid solutions

- Teams organized through Mass General Brigham
 - Mass General Brigham's **Center for Covid Innovation** is using their network to mobilize engineering teams; bringing people/resources together
 - 7 teams overall including the MIT Emergency Ventilator (E-Vent) team
 - Giner has been helping by making parts for these teams
 - Website: <https://covidinnovation.partners.org/>
- Giner utilizing equipment funded through DOE programs
 - Equipment: Laser cutters and 3D printers
 - Equipment originally used to fabricate hydrogen generator and sensor components, are being used to manufacture
 - Surgical face masks
 - Ventilator parts

Mass General Brigham
CENTER FOR COVID INNOVATION

Home Funding Devices Diagnostics Data & Analytics FAQ Contact Us

Interested in Joining our Therapeutics Pillar?

Join our virtual town hall on Friday, May 15th from 12:00PM – 1:00PM. A recording of the town hall will also be available after the event.

[Click here to join](#)

Our Mission: Facilitate the development of new innovations that flatten the COVID-19 curve and protect front line clinical staff across the MGB community and beyond

Reuse Group

Face Shields Group

Full Body Protection Group

Surgical Mask Group

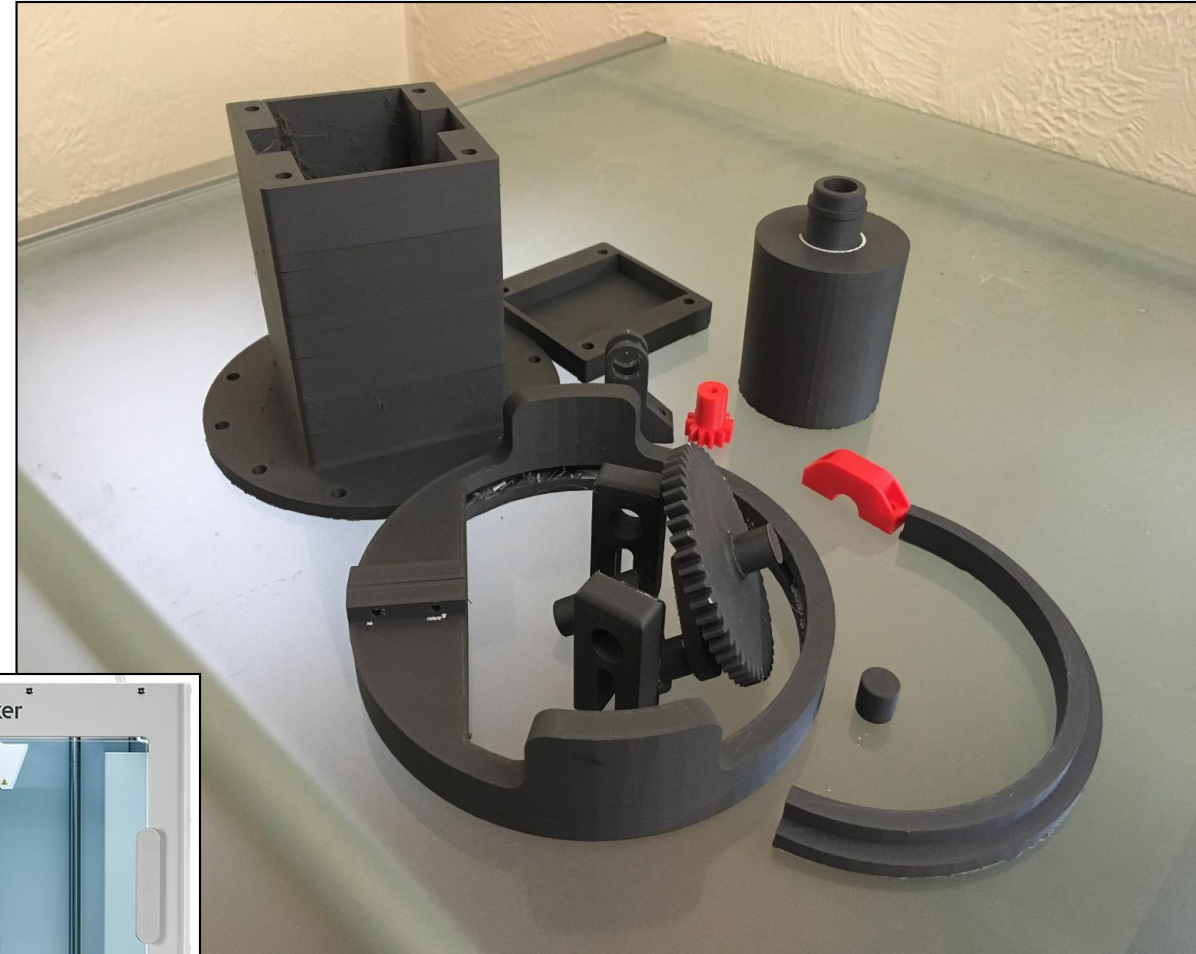
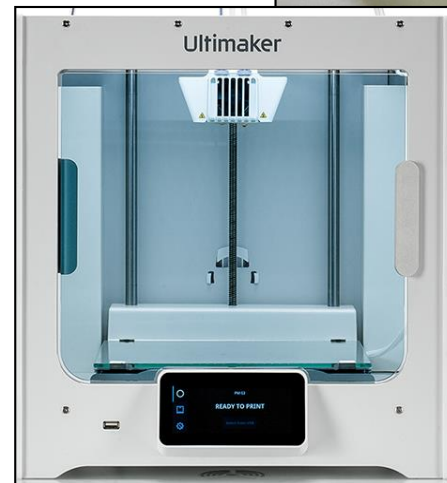
Ventilator Group

N95 Respirator Group

Direct-to-Consumer Group

Fabricating Ventilator Parts

- Giner is using 3D printer to print parts for Ventilator Groups
- 3D Printer purchased under DOE funded program: Portable Sensor for Detection of Micro-Organisms in Groundwater (contract #DE-SC0011307). Equipment originally used to fabricate
 - Components for field-deployable microbial monitoring systems
 - Prototype cell-frames; components used in PEM-based electrolyzers and fuel cell stacks

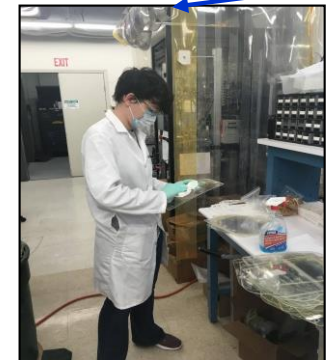
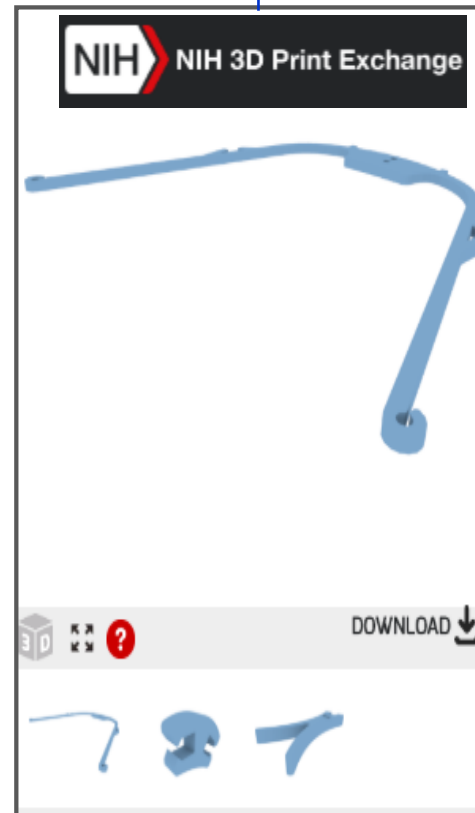
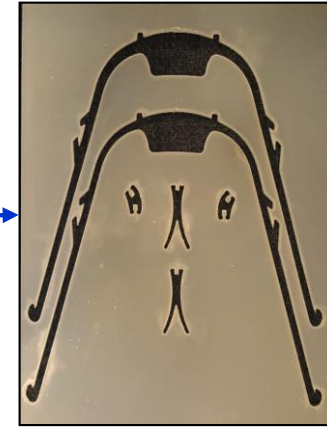


Fabricating Face Shields

- Giner is using laser cutters to fabricate complete parts for the Face Shield Groups
- Fabrication and assembling at Giner
 - Mfg. Capability: 120+ per day / 840+ per week
- Masks are donated to Harbor Health and Boston Health Care for the Homeless
- Laser cutter is cost-shared equipment on government contract
- Face shield is a NIH approved design: <https://3dprint.nih.gov/discover/3dpx-013456>



**Face Shields
fabricated and
assembled at
Giner Labs**



Future Activities

Giner is gearing up for a back-to-work phase in, but we will continue our efforts in fabricating PPE and ventilator parts until the demand subsides

The administration continues to work to acquire personal protective equipment (PPE) to support frontline workers

Coronavirus in Massachusetts: Governor Baker provides update on COVID-19 testing capacity and strategy, PPE procurement

Source : <https://www.wvlp.com/news> - May 15, 2020





Giner ELX Inc.
89 Rumford Ave, Newton, Ma. 02466

Monjid Hamdan
VP of Engineering
mhamdan@GinerELX.com

QUESTIONS?



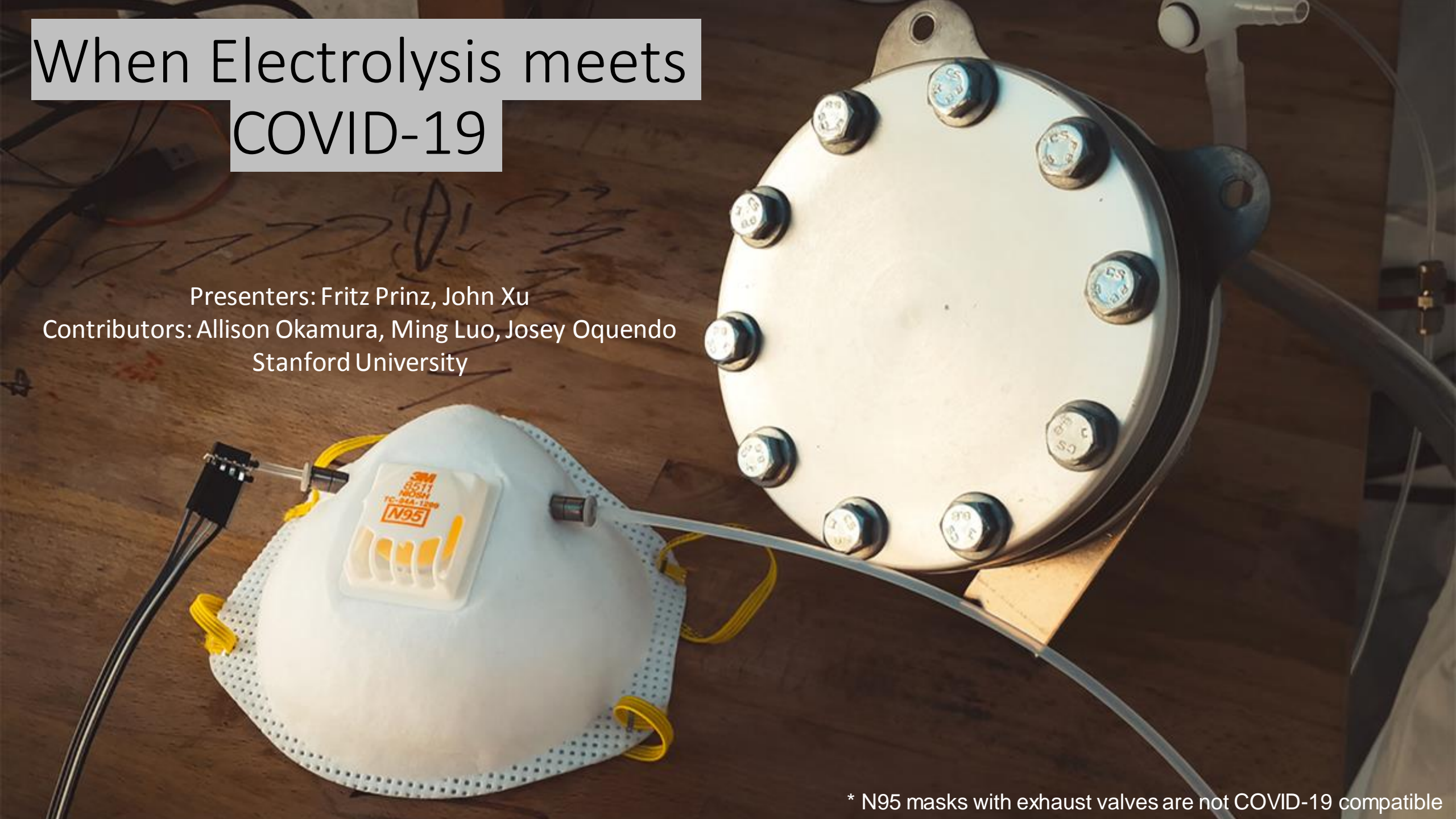
The #H2IQ Hour

Stanford University

When Electrolysis meets COVID-19

Presenters: Fritz Prinz, John Xu

Contributors: Allison Okamura, Ming Luo, Josey Oquendo
Stanford University



* N95 masks with exhaust valves are not COVID-19 compatible

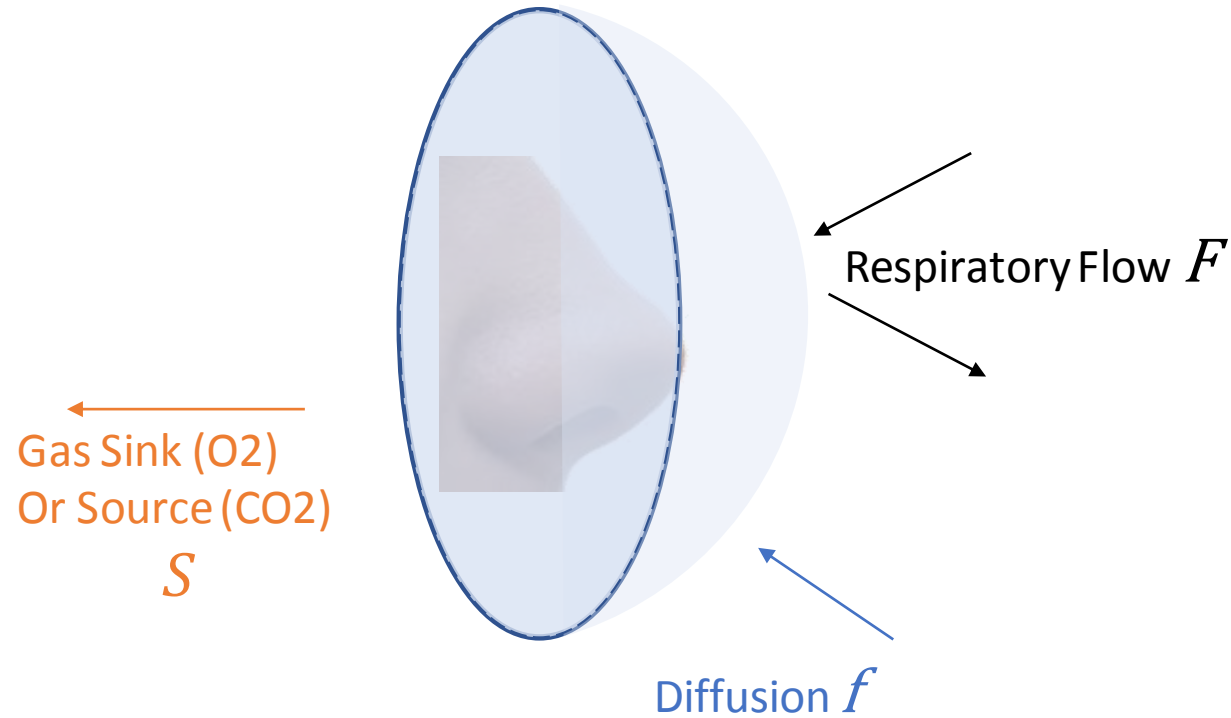


Sanitized Air

Filtered Air

+ Freshly Made Oxygen

The N95 mask model may suggest a need for both filtered air and a supplementary oxygen supply

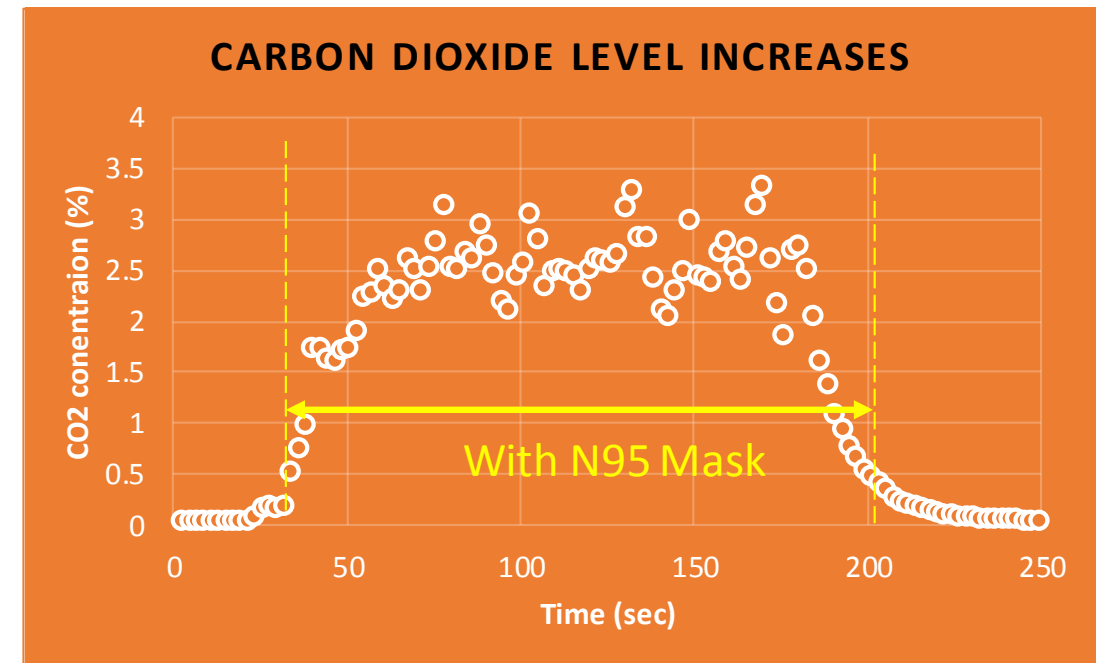
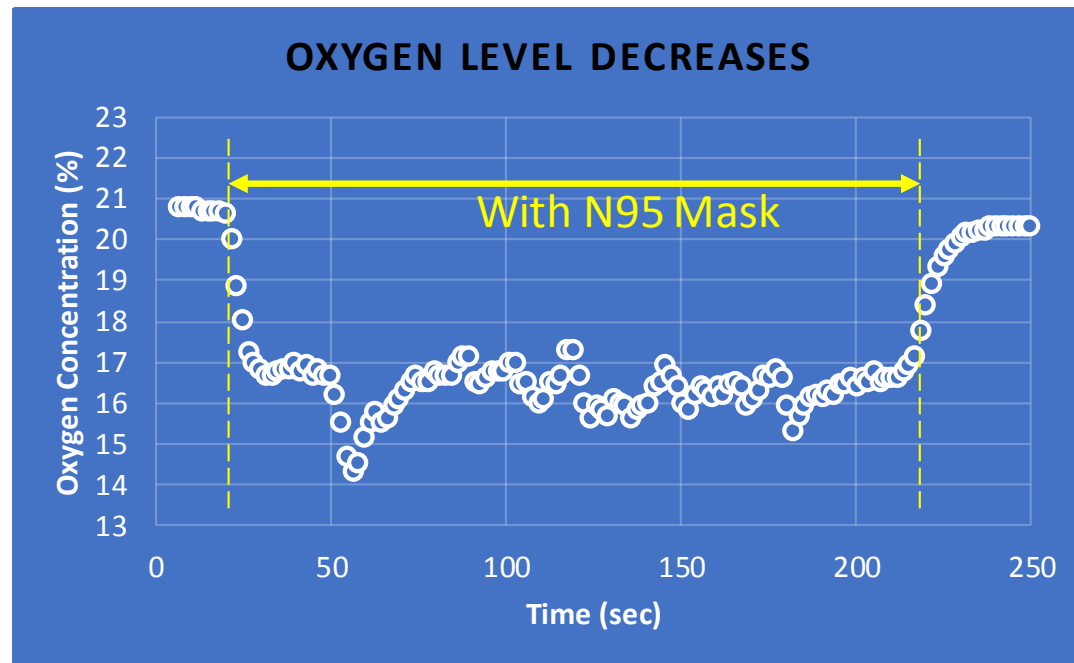


$$S_{O_2} = (F + f)\Delta p_{O_2}/p_0$$

Lack of Convective Mass Transport

$$\Delta p/p_0 \sim 4\%$$

Concentration change in the breathing environment



Respiratory Behavior Change

Table 4. Physiological Variables After 15 Min of Filtering Facepiece Respirator

	At Treadmill Speed 1.7 miles/h		
	Control*	FFR With Valve	FFR Without Valve
FFR Dead-Space Gases			
O ₂ (%)	NA	17.4 ± 0.6	17.3 ± 0.4
CO ₂ (%)	NA	3.0 ± 0.3	3.1 ± 0.2
S _p O ₂ (%)	98.5 ± 0.8	98.3 ± 0.7	98.3 ± 0.8
P _i CO ₂ (mm Hg)	40.7 ± 3.5	41.9 ± 3.7	40.3 ± 4.2
f (breaths/min)	27.7 ± 7.1	24.7 ± 6.6	23.8 ± 4.8
V _T (mL)	793 ± 215	967 ± 328	972 ± 321
\dot{V}_E (L/min)	20.9 ± 8.2	22.8 ± 5.6	22.2 ± 4.5
Heart rate (beats/min)	92.3 ± 8.2	96.6 ± 10.6	97.9 ± 8.3

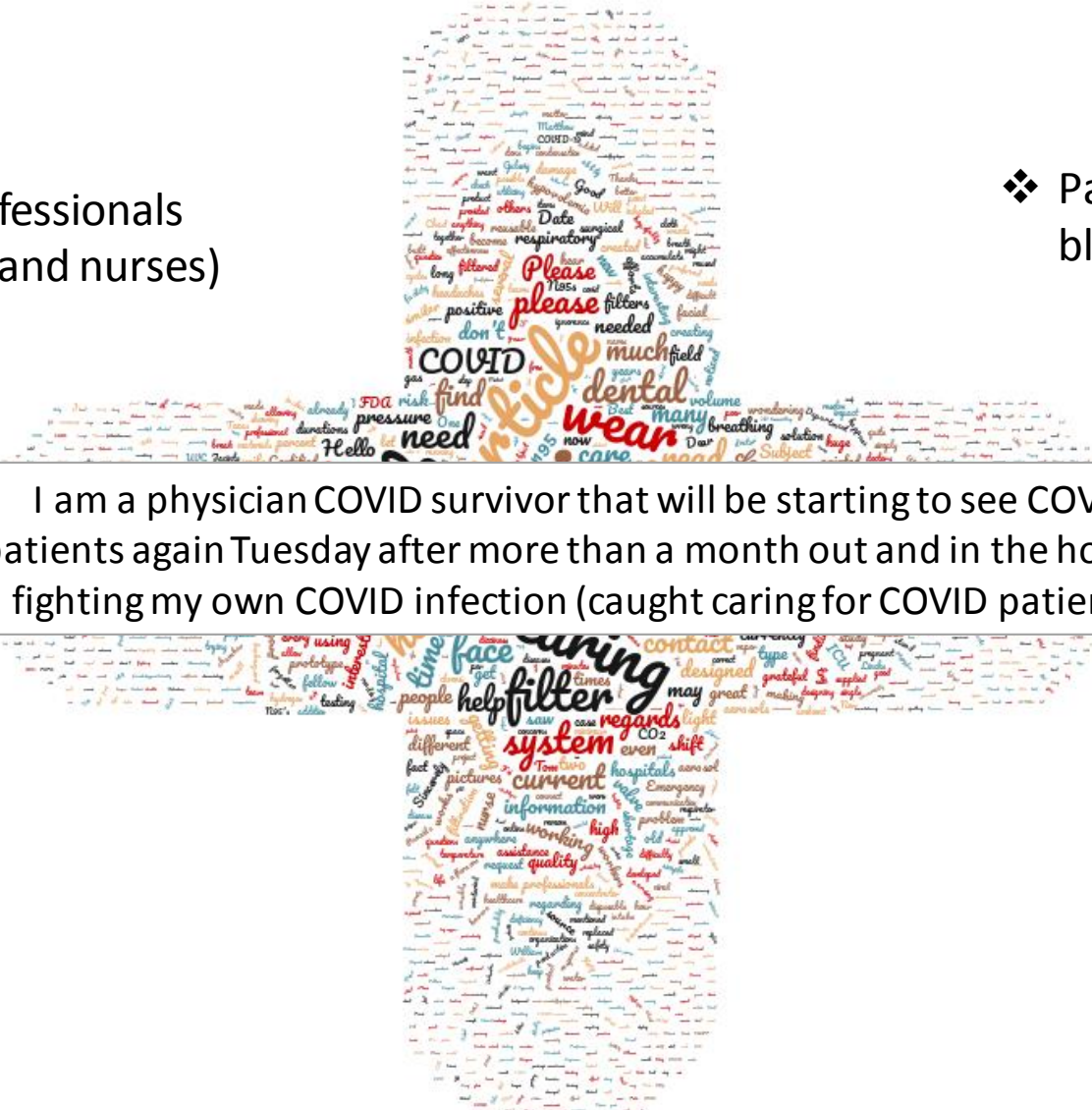
RJ Roberge et al., Respiratory Care, 2010, 55 (5), p569

Calls for a better N95 mask

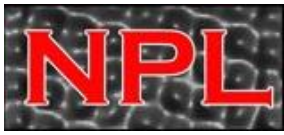
- ❖ Healthcare professionals (frontline doctors and nurses)

- ❖ Patients with respiratory and blood-oxygen related diseases

I am a physician COVID survivor that will be starting to see COVID patients again Tuesday after more than a month out and in the hospital fighting my own COVID infection (caught caring for COVID patients)



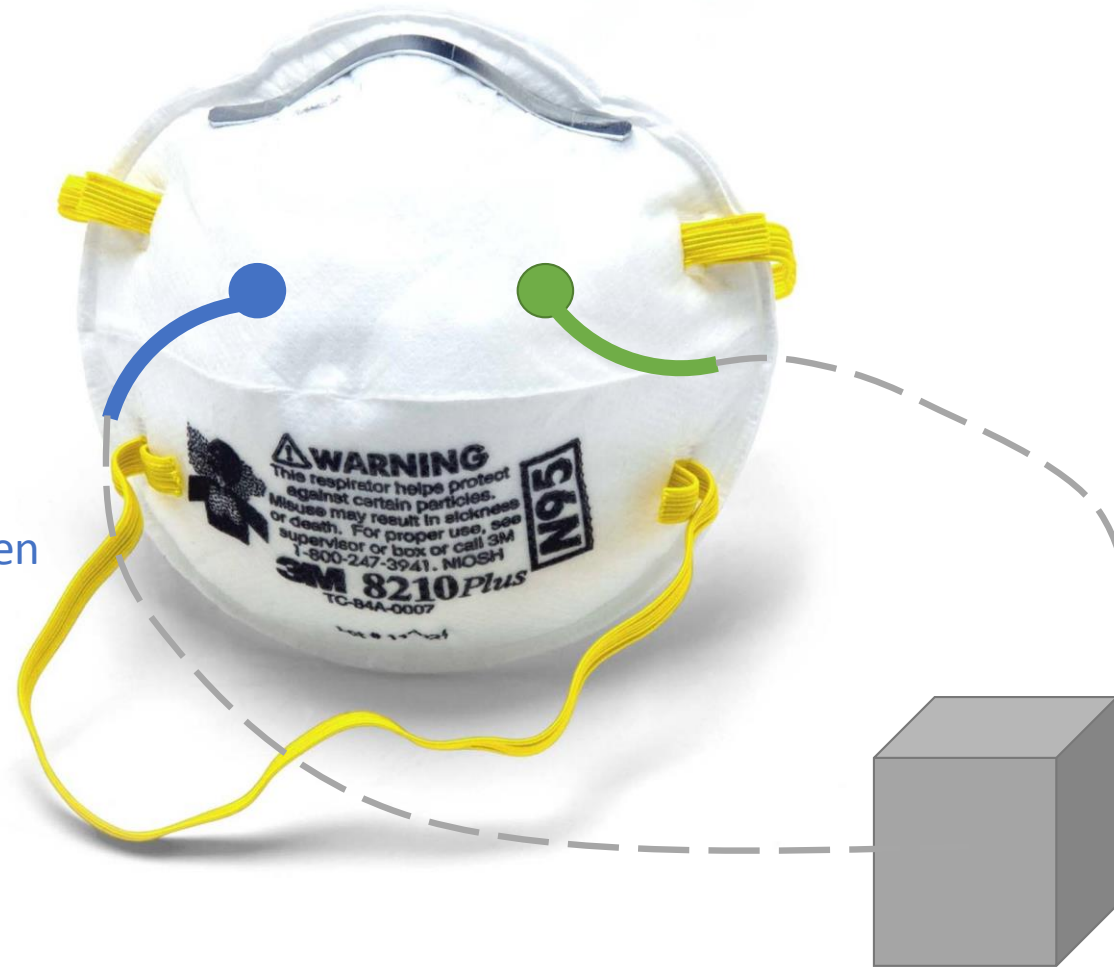
Word cloud generated by requests/questions on the "reengineered" mask



Dr. Shicheng (John) Xu
Prof. Fritz Prinz



Prof. Allison Okamura
Dr. Ming Luo
Yousi (Josey) Oquendo



① Small amount of pure, clean oxygen

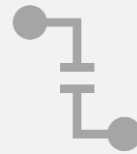
② Active Venting to reduce CO2 and moisture

A Wearable Conditioner

Work Scopes



Respiratory responses to the gas levels in the breathing environment



Oxygen generator/CO₂ remover that fits into the form factor

Stanford | ENGINEERING

Electrochemical oxygen production

Electrolyzer + Fuel Cell

Electrolyzer: $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$

Fuel Cell: $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

Direct oxygen enrichment

Cathode: $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$ Pt/Co

Anode: $2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4\text{e}^-$ IrO₂

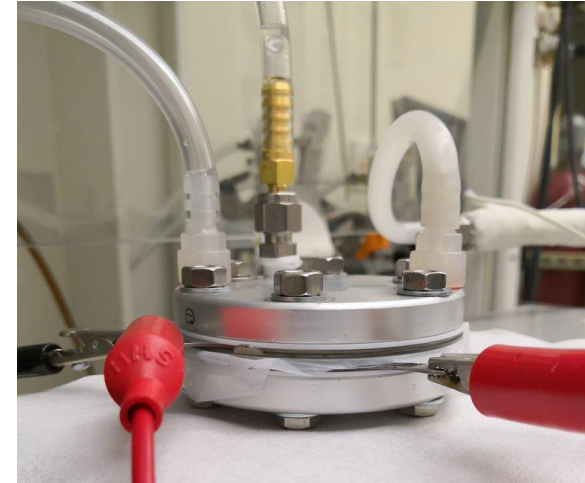
(25 °C) 1.1 V | 0.3 A/cm² | 1 sccm O₂/cm²

Capacity estimate

N95 conditioner: 100-200 sccm -- 30-60 W/unit

Medical grade oxygen generator: 2-4 slpm 0.6-1.5 kW/unit

Total capacity can mount to GW/year



More research directing towards

- Active OER/ORR catalysts
- Small form factor stacks
- Potentially a direct electrochemical disinfection process



The #H2IQ Hour Q&A

Please type your questions into the **Q&A Box**

Q&A ×

All (0)

Select a question and then type your answer here, There's a 256-character limit.

Send

Send Privately...

INCREASE YOUR

H₂IQ

The #H2IQ Hour

Thank you for your participation!

Learn more:

energy.gov/fuelcells
hydrogen.energy.gov