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TECHNOLOGIES INC.

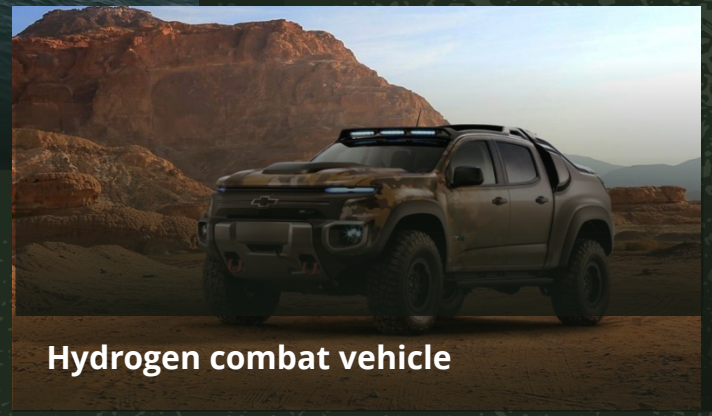
# Domestic landscape of hydrogen fuel cells and fuel cell materials

**Gary Ong, Co-founder & CEO**

**garyong@celadynatech.com**

# HYDROGEN EXTENDS OPERATIONAL PROFILE BEYOND BATTERIES

Fuel cell UUV for the Navy

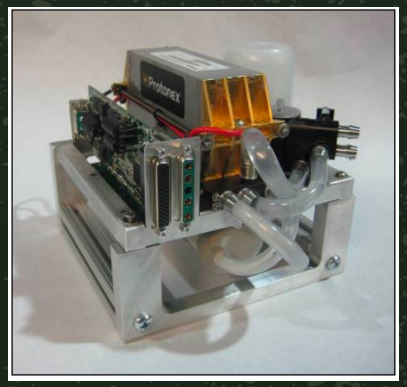


Hydrogen combat vehicle

Hydrogen has been piloted by the DoD already

Fuel cell power unit for infantry

| Class 2 UAV (Work by NRL) | Fuel cell | Li-ion battery |
|---|---|---|
| Specific energy | 1100 Wh/kg | 200 Wh/kg |
| Propulsion system weight for 24 hours flight time @ 300W | 7 kg | 30 kg |





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**Source** | Matthew Goldberg, "Death and Injury Rates of US Military Personnel in Iraq," Military Medicine, 175, 4

# Build hydrogen, Stay competitive

**We are losing the supply chain for fuel cells: to China. Like batteries and solar.**



**Source** | Matthew Goldberg, "Death and Injury Rates of US Military Personnel in Iraq," Military Medicne, 175, 4

## For the DoD

The world is transitioning to hydrogen, and we need to make this a tactical advantage.

## For Celadyne/USA

China controls 35% of the supply chain right now to make electrolyzers and fuel cells.

Over 80 % of membrane materials are manufactured in China today.

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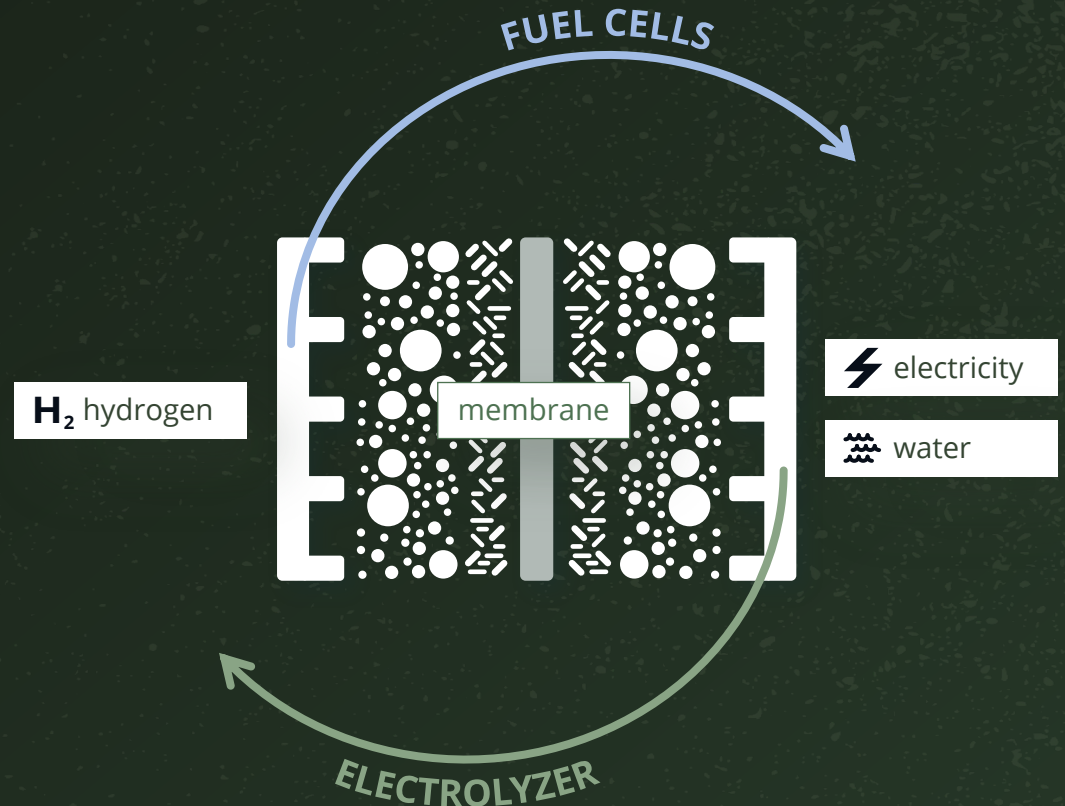
# BUILDING FUEL CELLS & ELECTROLYZERS WITH MATERIALS

Fuel cells convert green hydrogen into electricity and water

$H_2$ → 〰 + ⚡

Electrolyzers convert renewable electricity and water into green hydrogen

〰 + ⚡ → $H_2$



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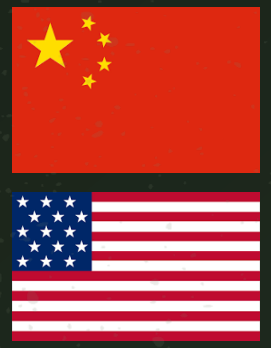
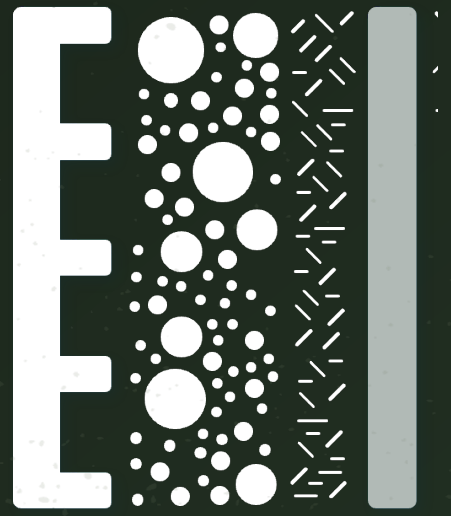
# USA IS LOSING THE MATERIALS SUPPLY CHAIN

Plates



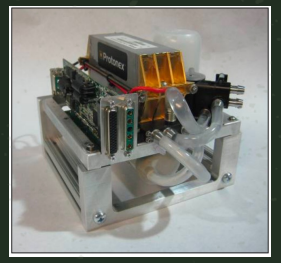
Electrodes

Membranes



Stacks





Devices



# CELADYNE TECHNOLOGY REDEFINES FUEL CELLS & ELECTROLYZER PERFORMANCE

## CELADYNE'S CONTRARIAN COATED MEMBRANE TECHNOLOGY BLOCKS HYDROGEN FOR DURABILITY AND EFFICIENCY

- Membrane precursors are common materials used to make shoes and cookware, so there is no need to scale up new polymer chemistries.
- Our coating process is performed under room temperature and pressure conditions similar to spray-painting, avoiding expensive vacuum processing

## IMPACT

- No switching costs by leveraging pre-existing fuel cell and electrolyzer technologies
- More durable membrane technology eliminates the root cause of fuel cell failures
- Thinner membranes create more efficient electrolyzers

CELADYNE PATENTS: 63/331,007 | 63,347,715

*Benchmarked to Department of Energy standards and specs.*



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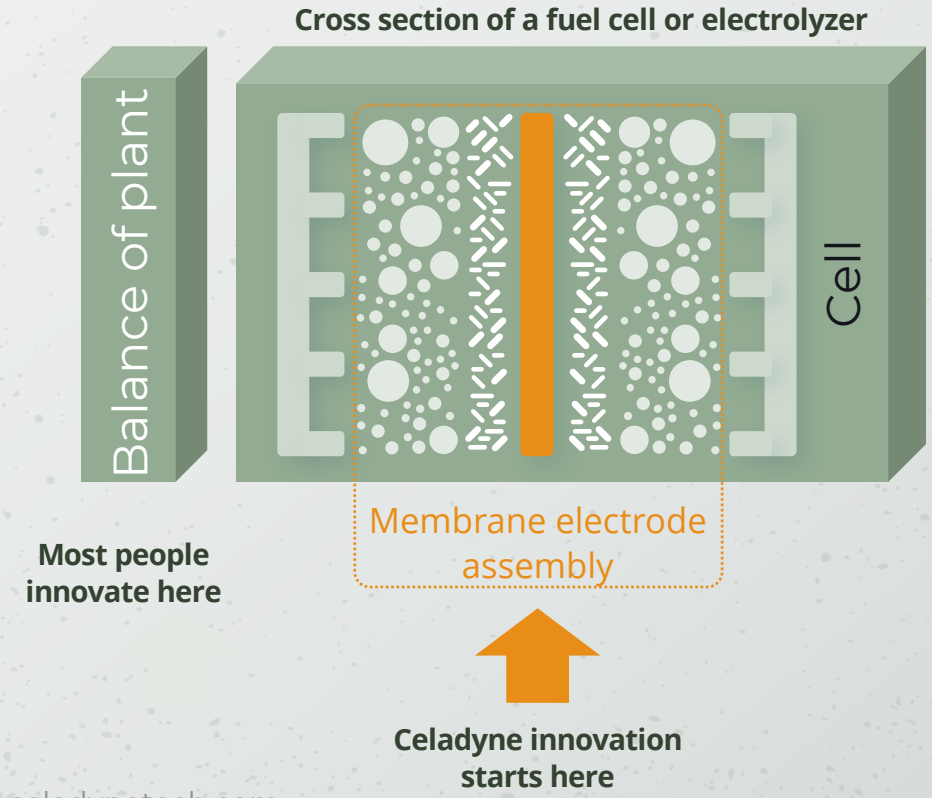
# MATERIALS PLATFORM ANCHORS DOMESTIC FUEL CELLS AND ELECTROLYZERS




## Celadyne materials get us:

**01** Proton exchange membrane

**02** Platinum catalyst

**03** Porous carbon layers

**20%** efficiency improvement

**5x** durability (15 years)

**Not so secret sauce:** We solve hydrogen permeation – the basis for poor hydrogen safety and durability

CELADYNE PATENTS: : 7 X pending

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# CELADYNE STRATEGY FOR THE DOD

Enable 2-5 kW fuel cells for small autonomous systems

Enable compact hydrogen refueling

Enable large 50 - 300 kW manned and unmanned systems

Enable base load resiliency and generation



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# Celadyne has shipped membrane technology

Lubrizol GORE SOLVAY

**Chemical manufacturers**

We are undertaking a mutual evaluation with multiple chemical manufacturers.

gm BALLARD TOYOTA

**Fuel cell developers**

We have shipped paid POCs with two more paid evaluations requested in the pipeline

ohmium nationalgrid

**Electrolyzer developers**

We are finalizing a pilot with National Grid (a utility company) for a 5 kW pilot electrolyzer utilizing Celadyne technology.

U.S. AIR FORCE

UNITED STATES SPACE FORCE · DEPARTMENT OF THE AIR FORCE · MMXIX

UNITED STATES ARMY

UNITED STATES NAVY

*Funding and programmatic*

*Testing and facilities*

**Military traction**

illuming power energy innovation

UNMANNED AEROSPACE

Intelligent Energy

GENERAL ATOMICS

**Defense traction**



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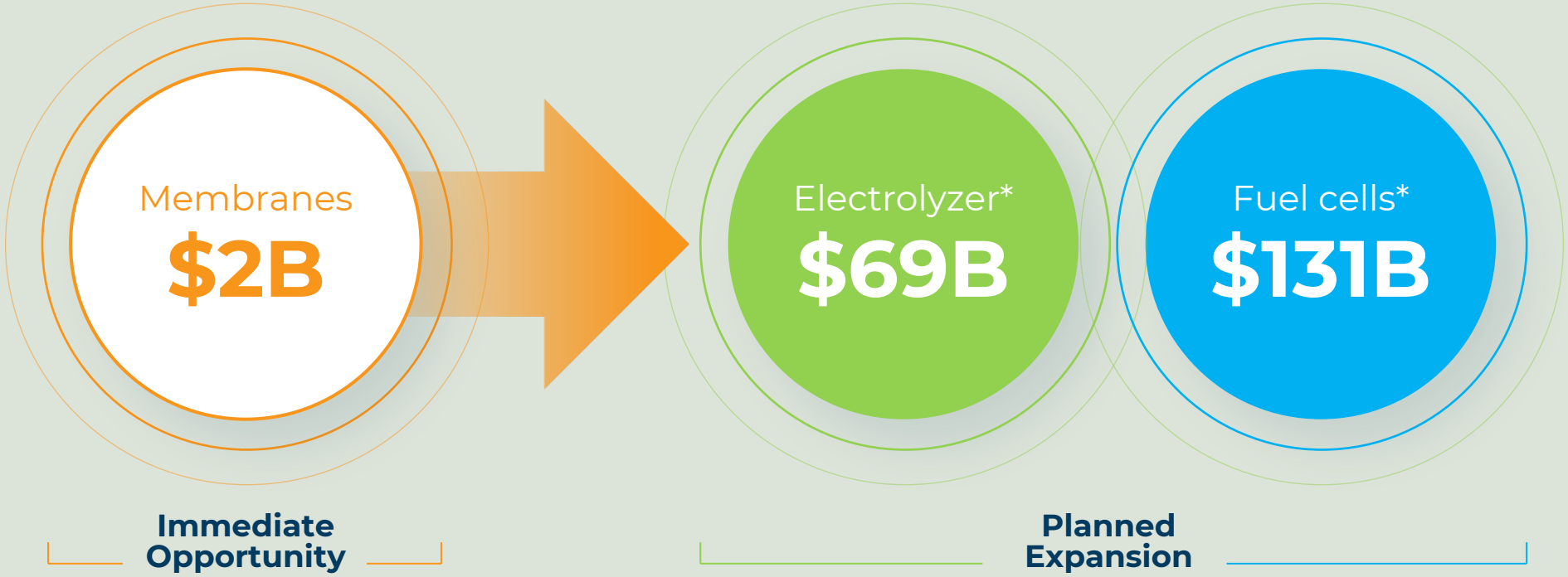
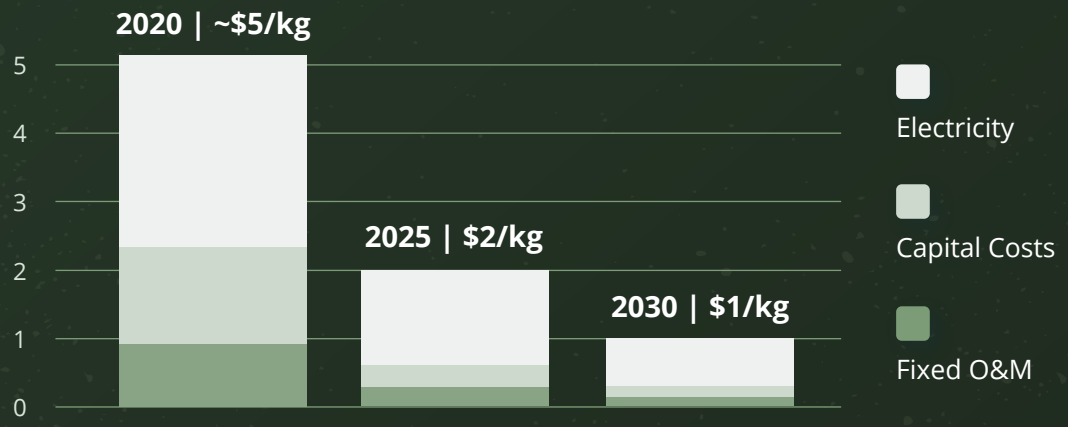
# Rapidly expanding market opportunity for fuel cells and electrolyzers expected to reach $200B by 2030



# WE CAN TURN HYDROGEN ENERGY INTO A TACTICAL ADVANTAGE

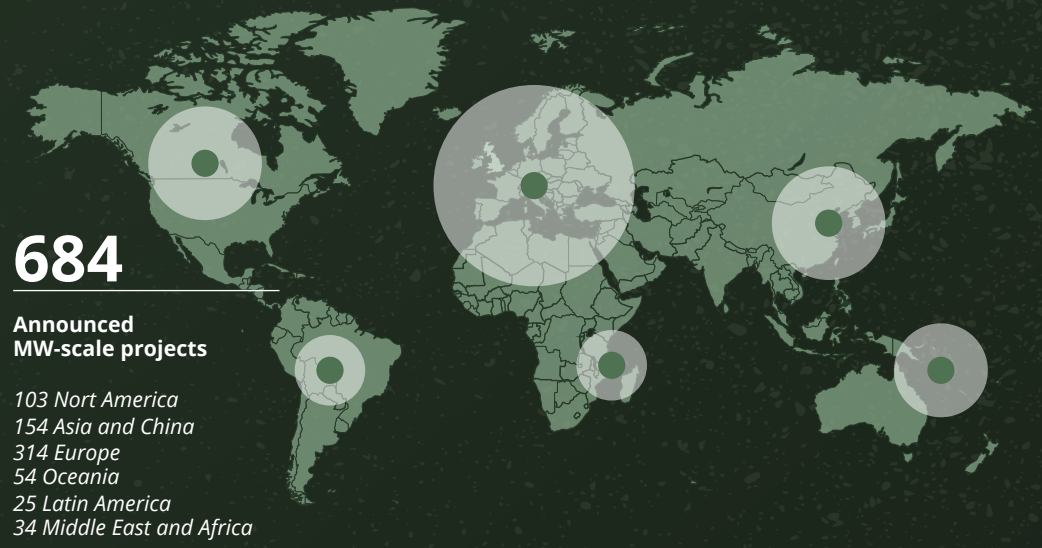
**Example: H2 cost from PEM electrolysis**




The **Inflation Reduction Act** in the US provides up to a $3/kg subsidy for green hydrogen, immediately accelerating cost reduction by 5 years

More than 680 large-scale projects have been announced globally, with a focus on production, industrial usage, transport, and infrastructure.

*684 announced megawatt-scale projects*




Almost every industrial player has announced projects on hydrogen. The projects represent up to $240 billion in direct investments.



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# OUR TEAM ARE FOUNDERS WITH DEEP TECHNICAL EXPERTISE IN FUEL CELLS, ELECTROCHEMISTRY AND MATERIALS

**Gary Ong**

- Founder and CEO
- Mat. Sci PhD from UC Berkeley
- Sputnik ATX graduate 2019
- Argonne CRI fellow 2019

**Toru Hatsukade**

- Senior Electrochemist
- Chem. Eng. PhD from Stanford
- Argonne post-doc and former fellow at Karlsruhe Institute of Technology

**Corey Staller**

- Director of Engineering
- Chem. Eng. PhD from UT Austin
- Forbes 30 under 30
- Senior Engineer at Micron previously
- 7 year working relationship with Gary

**Delia MIliron**

- Co-founder and CSO (advisory)
- Chemistry PhD from UC Berkeley
- Chair of Chem. Eng. at UT Austin
- Cofounder of Heliotrope (Series B)

**13 TOTAL FTE**



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## TECHNICAL

### John Kopasz

Lead for DOE Fuel Cell Technologies Office (Membranes)

Led DOE fuel cell membrane development effort for > 17 years

PhD Chemist at Argonne

### Debbie Myers

Group Lead of the Hydrogen and Fuel Cells Materials Group at Argonne

Leads DOE fuel cell catalyst effort for heavy duty fuel cells

PhD Chemist at Argonne

### Benny Freeman

Director of the University of Texas, Austin Center for Water and Energy Systems

World expert in gas and water separation membranes.

PhD Chem. Eng. at UT Austin

## COMMERCIALIZATION



### Steven Freilich

Former CTO and Director of Engineering at DuPont

### Ron van Dell

Former CEO of

ViZn Energy Systems - a redox flow battery startup

SolarBridge Technologies (acquired by SunPower 2014)

Primarion Inc. (acquired by Infineon Technologies 2008)

### Dan Goodman

Startup mentor across NYSERDA, FedTech, Breakthrough Energy, TechStars

Managing Partner at Sandy Springs Climate Partners

# OUR ASK

01

Phase III work together

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02

Letters of support for a Phase 2 grant to the Army.

03

Partner for an **OECIF or DIU work for hydrogen implementation.**

## PROJECTS LOOKING FOR SUPPORT

### FUEL CELLS INTEGRATION

### ELECTROLYZER INTEGRATION

U.S. AIR FORCE

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# THANK YOU!

**Gary Ong, Co-founder & CEO**

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One-Pager

# MAKING THE CASE FOR HYDROGEN TRANSFORMATION

**01** **AUTONOMY, AI AND EDGE COMPUTING**

Need high density fuels to power sensors and computation.

**02** **MODERNIZATION OF THE GRID AND ENERGY**

The world is moving to an electron backbone. The ones who can make fuel from that wins.

**03** **DISTANCE, AGILITY AND CONTESTED ENVIRONMENTS**

Need high density fuel you can get or generate anywhere.

**WE BELIEVE THE FUTURE OF FUEL IS IN HYDROGEN**



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