



carbenTM

A Nabors Company

Carbon Nanomaterials: Delivering Clean Energy Breakthroughs

May 2023

Business Overview





Summary Highlights

- ① **Leader in Emerging Carbon Tech Industry**
CARBEN produces high-value, synthetic graphene from hydrocarbons or waste materials
- ② **Advantageous Production Method**
CARBENHex is created at low cost and with near-zero emissions, displacing incumbent processes
- ③ **Massive Addressable Potential**
As a material additive and technology enhancer, graphene holds near limitless potential in various energy, industrial and material markets
- ④ **Blue Chip Backing, Global Footprint**
CARBEN is wholly owned by Nabors Industries (NYSE: NBR), a multi-billion-dollar energy technology company with operations in more than 15 countries

Leadership



SIGGI MEISSNER

**PRESIDENT, NABORS ENERGY
TRANSITION SOLUTIONS**

Siggi is the President of Nabors Energy Solutions and heads the CARBEN leadership team. He holds 40+ years of industrial experience, having led and managed engineering teams across the world.



EVAN JOHNSON

CHIEF TECHNOLOGY OFFICER

Evan leads the R&D team, driving the innovation of and development for all graphene production and new graphene applications. His 15+ years of executive experience in alternative energy has led to over 25 patents.



JOSE MORALES

**BUSINESS STRATEGY &
DEVELOPMENT**

Jose is responsible for establishing contract and customer set-up, driving business strategy, managing enterprise support and conducting market research.



MARK HARTLE

DIRECTOR OF APPLICATIONS

Mark is responsible for overall business development including cement, batteries, and polymer applications. Mark has an MBA focused on Energy and 15+ years of operations and commercial experience

Net Zero: Easier Said Than Done

Gaps to a Clean Energy Future



Technology Limits

50% of the world's needed emissions reductions require technology that isn't commercially available today (IEA 2021)



Supply Chain Risk

Rising prices and supply shortfalls for rare earth metals
Major ESG implications for mining rare earth metals
Growing reliance on China for rare earth metals



Hard-to-Abate Segments

Major portion of the industrial economy – which represents about 30% of global emissions – can't be electrified

The Solution

Graphene is widely regarded as the “miracle particle”

- 200x stronger than steel
- 6x lighter than steel
- 100x higher conductivity than computer silicon
- 70% more conductive than copper
- Highly transparent
- High elasticity
- Minimizes electrical power loss
- **Substitute for foreign-sourced, rare-earth metals**

Near Limitless Applications

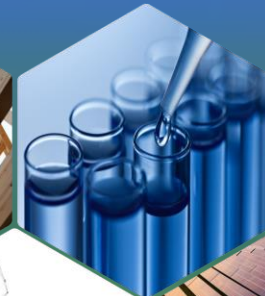
Structural

Concrete & Cement
Polymers
Carbon Fibers
3D Printing



Medical

Tissue engineering
Bioimaging (MRI)
Drug delivery
Biomicrobotics
Biosensors



Electronics

Transistors
Superconductors
Frequency multiplier
RF Technology



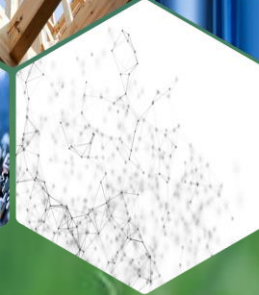
Energy

Solar cells
Light collector
Electrode
Fuel cell
Thermoelectric
Energy storage
Capacitors

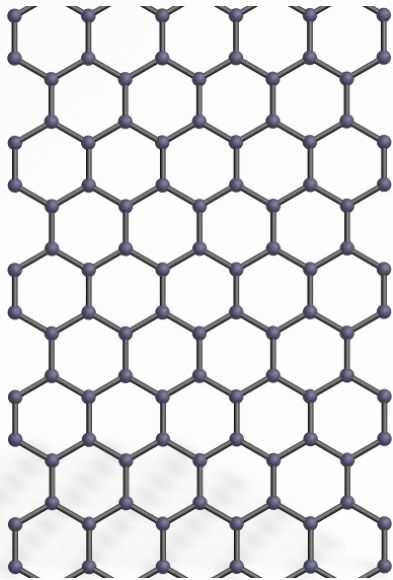


Fluids

Lubricants
Thermal Coatings
Coolants
Water filtration
Paints

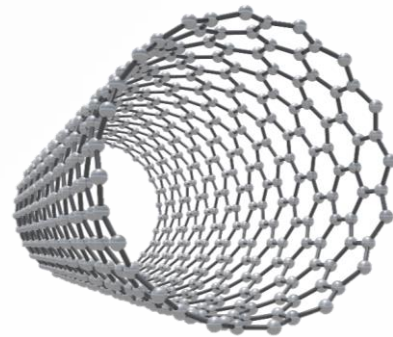


Graphene Structures



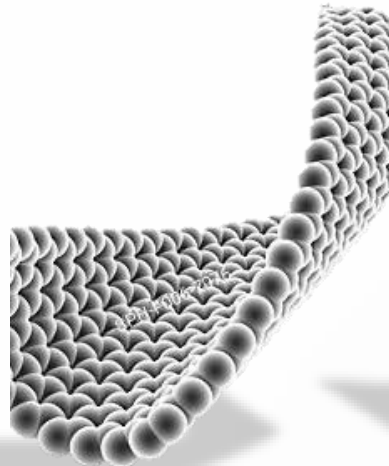
Monolayer

A single sheet of one atom thick carbon atoms



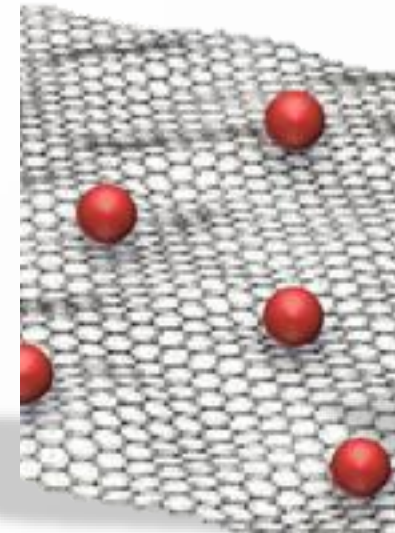
Nanotube

A monolayer sheet rolled into a tube, used for tensile properties



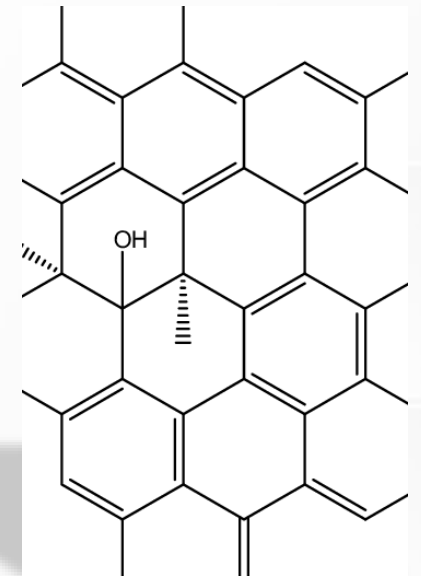
Nanosphere

A sphere of carbon atoms, key for energy and gas storage



Doped Graphene

Phosphorus, sulfur, nitrogen, oxygen, and other materials inserted into the graphene matrix to enhance the applications of graphene



Flakes (GQDs)

Multiple fragments of monolayer graphene


Graphene Production Today

Graphene is manufactured in a powder form and is usually found as one of 3 types.

Due to its high production costs, current methods of graphene production are used in small quantities to enhance certain products and large-scale productions are limited.

	Chemical Vapor Deposition	Physical Exfoliation	Liquid Exfoliation	Flash Graphene Technique
Scalable	X	X	✓	X
Cost	Low	High	High	Low
Speed	Slow	Slow	Slow	Fast
Proven Material Consistency	Inconsistent	Inconsistent	Inconsistent	Unknown
Environmental Impact	Varies	Varies	Varies	Low
Graphene Type				
Graphene Structures				

Graphene Types Today

High Quality	Types of Graphene	Applications
	Single Layer Graphene	Electronics, energy storage, biosensors, research initiatives
	Single & Multi-wall CNTs	Conductive materials, lubricants, structural materials, thermal applications, energy storage
	Reduced Graphene Oxide	Composites materials, conductive inks, sensors, electronics, supercapacitors
	Graphene (2-10 layers)	Nanofillers – polymers, concretes, metals etc., industrial, energy storage, electronics
	Graphite	Lubricants, steel, industrial applications, energy storage
Low Quality		

Graphene Challenges

Primarily Derived from Graphite, Which Poses Significant ESG and Supply Chain Risk

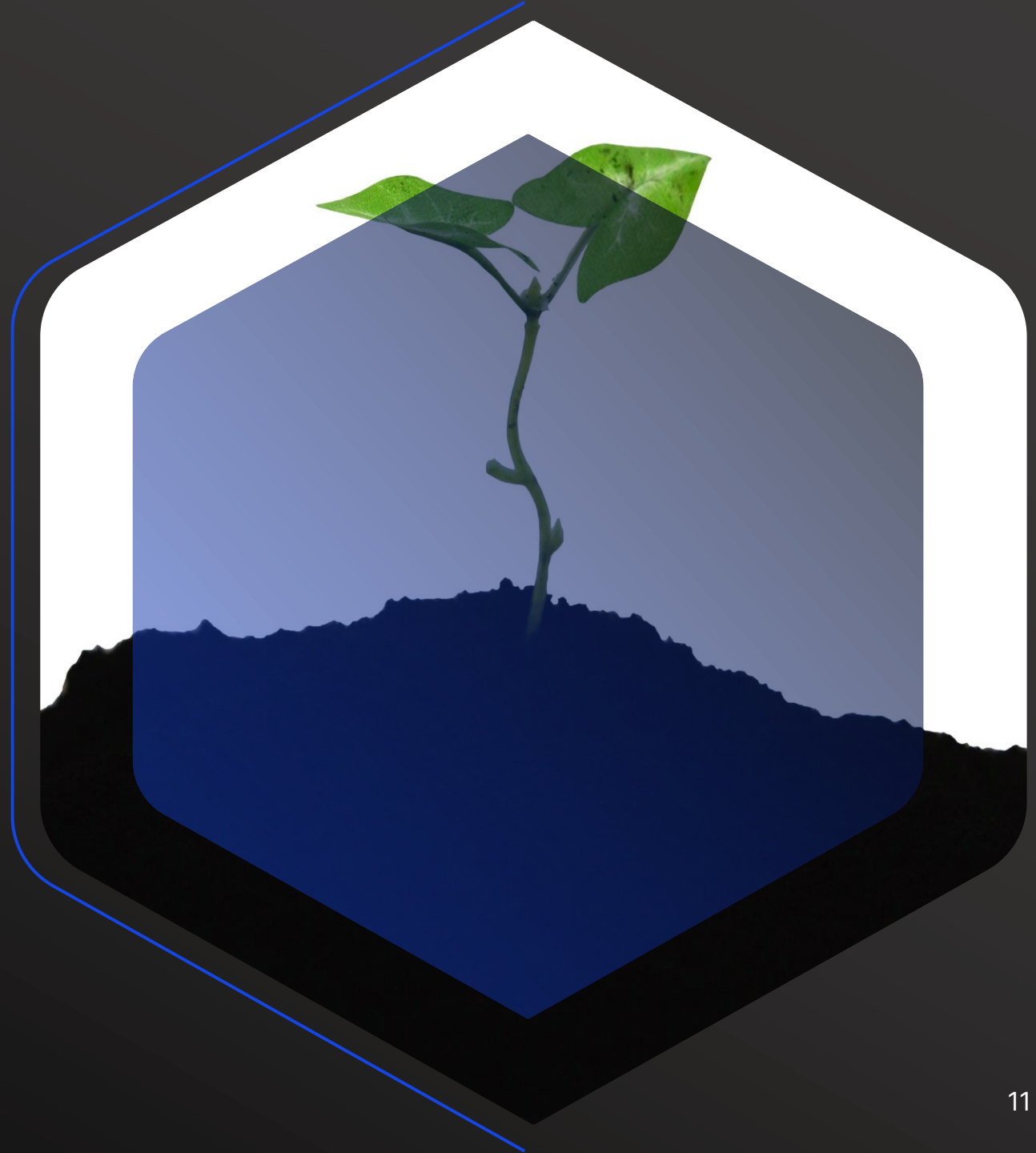
- 1 kg of natural graphite mined in China produces 16.8 kg of CO₂e emissions
- US relies 100% on imports, primarily from China
- Graphite shortage expected to grow to 8 metric tons by 2040, largely from battery and EV demand

Several False Starts

- Product quality is often contaminated with oxides
- Lack of proven solutions to efficiently and economically produce bulk amounts
- Product quality is highly inconsistent



Technology Overview



Our Solution **CarbenHex™**

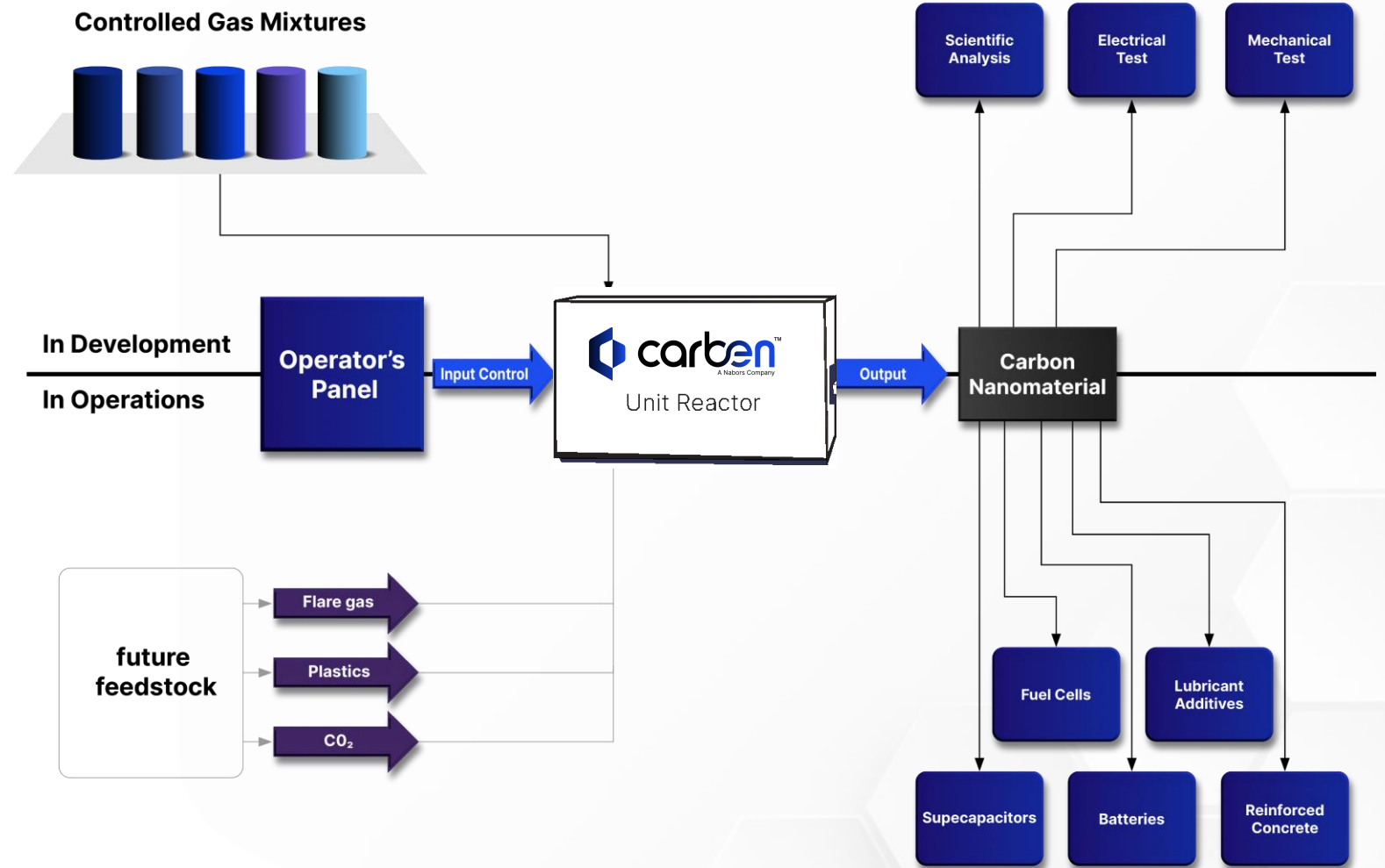
CARBEN processes a proprietary blend of hydrocarbon gasses and chemistry to create a unique pure graphene structure

CarbenHex™ spheres are like an onion, with multiple single layers of graphene, which holds unique characteristics and properties

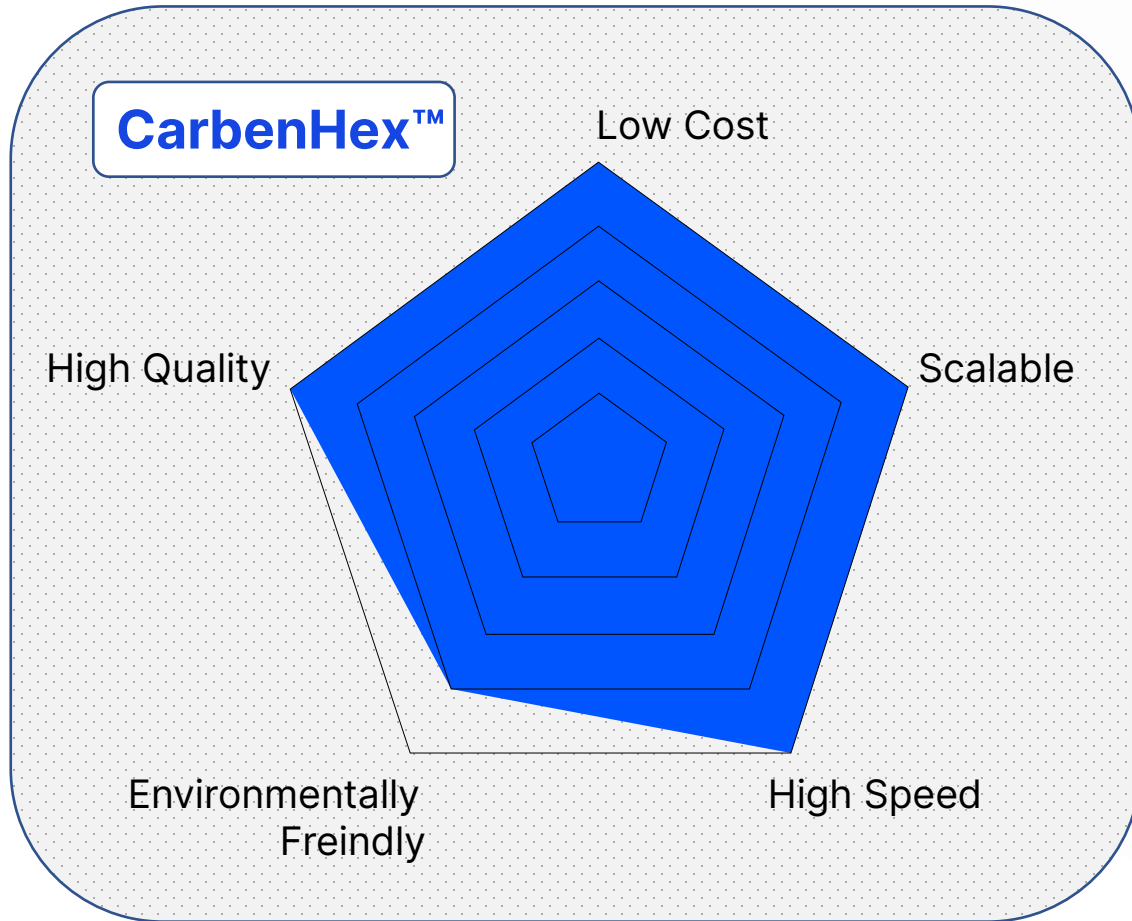
Our Method

Delivers Distinct Advantages
Over Legacy Processes

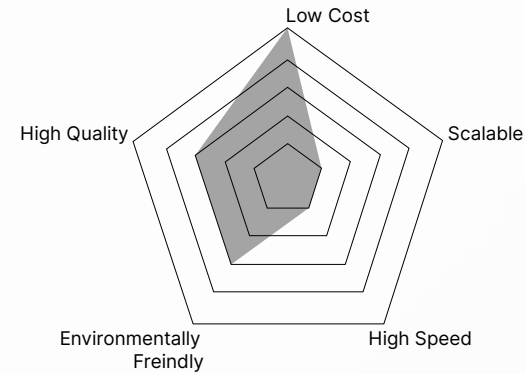
- Scalable
- Low cost
- Fast production
- Material consistency
- Minimal environmental impact
 - Near zero CO₂ emissions



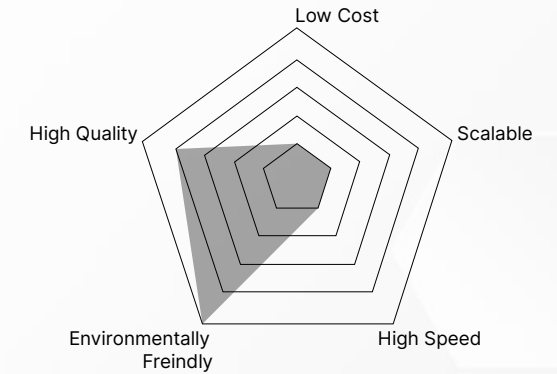
All Graphene is Not Created Equal



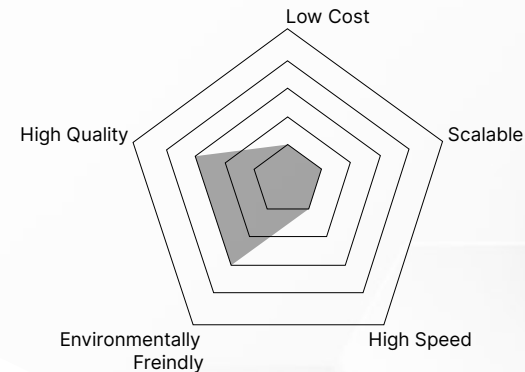
Chemical Vapor Deposition



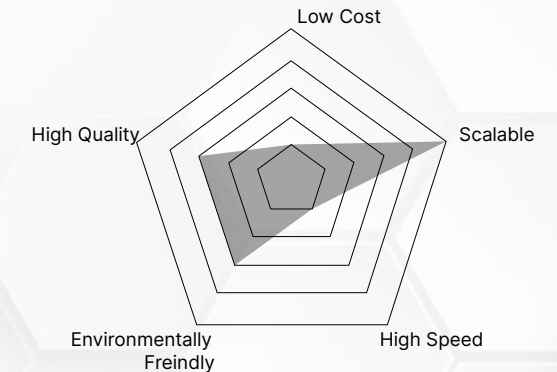
Flash Technique



Physical Exfoliation



Liquid Exfoliation

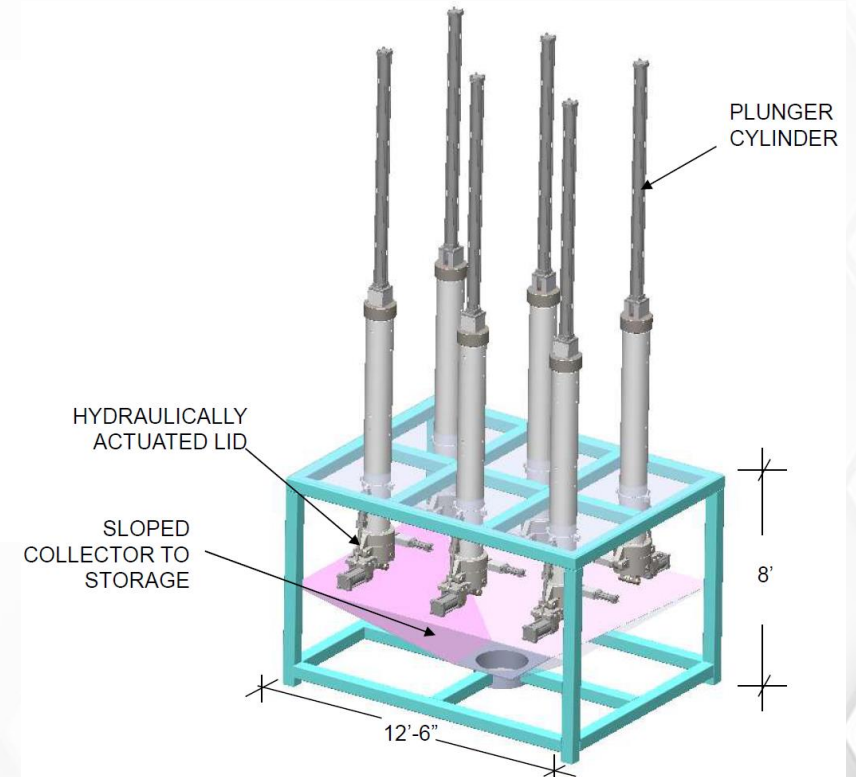
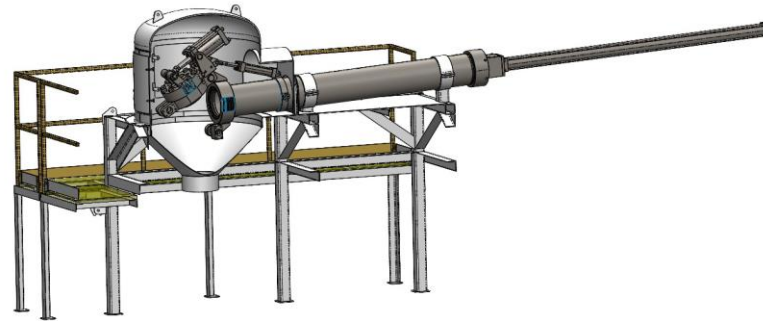
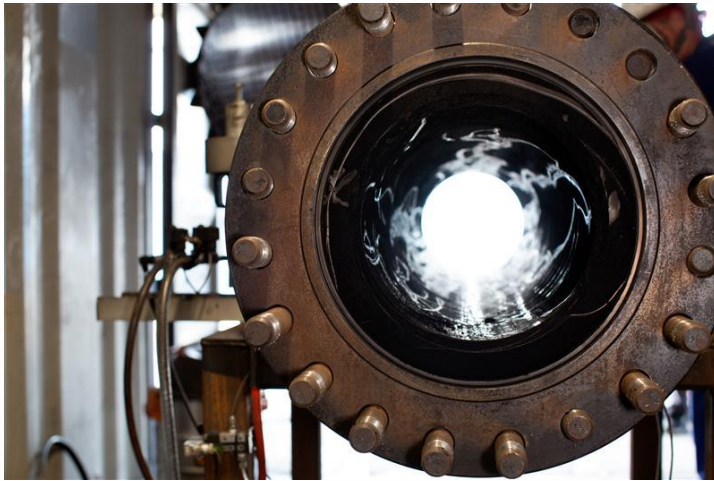


Path to 1,000 Metric Tons and Easily Expandable to 10,000 Metric Tons to Meet All the World's Needs

Today's Technology



Scalable, Fully Automated



New Cx Formulations

Cx Silicates ✓, Cx encapsulated metals ✓, Ozonated Cx oxide ✓



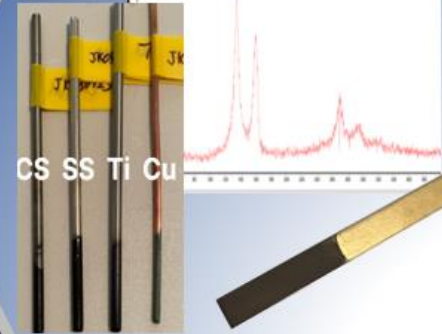
Military



Command Strategies ✓
Multiple Project Interests ✓
New EMP and Stealth ✓

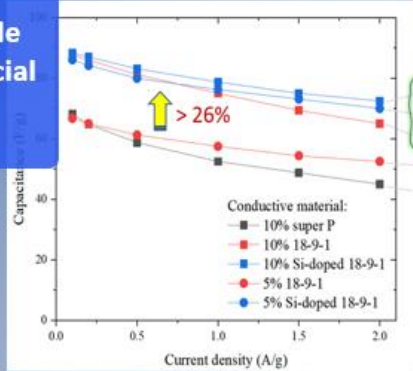
Electroplating

Raman spectroscopy verifies Cx



Proof of Concept ✓
IP Disclosure ✓
Multiple Materials anode and cathode ✓
MATCHA verified ✓

Capacitors



TAMU sees increased capacity more than 26% over super P graphene ✓
UCAP observes notable increase our commercial with Cx ✓

Batteries



Carben Hex/Silicon best performance ✓
ARI development agreement ✓
Increased in house testing 30% ✓

Carben Hex

Research & Development

Applications

Hydrides



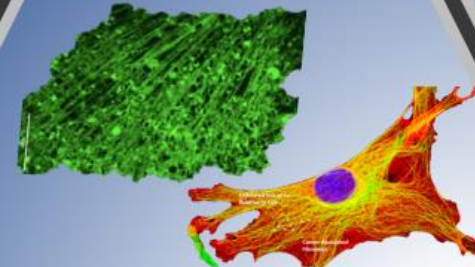
Carben Hex hydride proof of concept demonstrated ✓

Filters



Heavy Metals
Pharmaceuticals
Desalination

Biomedical



NRI demonstrated adsorption and uptake for delivery ✓
RF excitation in cells for apoptosis concept shown ✓
IP Disclosures ✓

CONFIDENTIAL

Epoxy/Corrosion Resistance

Testing

Texas A&M has conducted extensive testing with CarbenHex® in epoxies across four ASTM evaluations and accelerated life testing of corrosion resistance

Value Proposition



Improved performance & corrosion resistance



Advanced applications and extended asset life

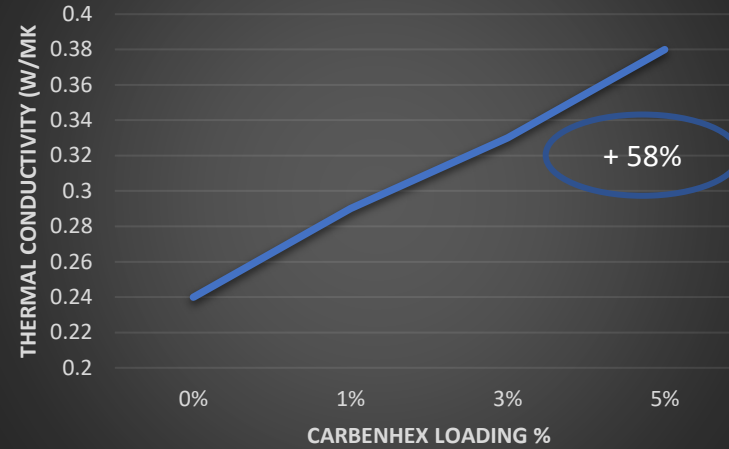
Use Cases:

Advanced coatings for harsh environments

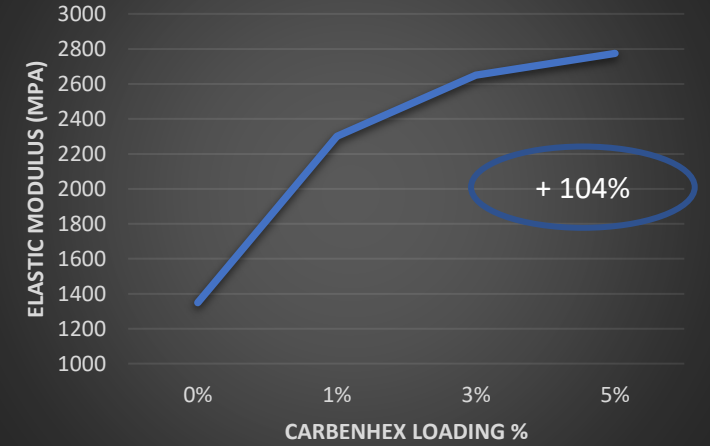
Carbon Fiber and textile enhancement

Advanced light-weighted composites

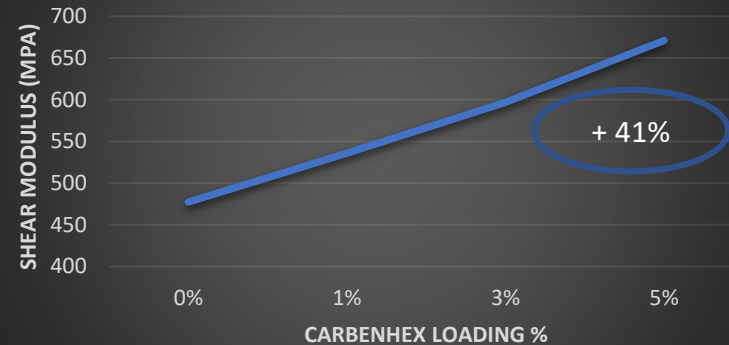
Thermal Conductivity



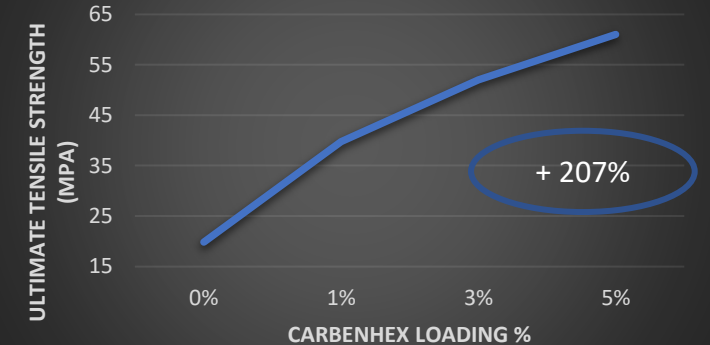
Elastic Modulus



Shear Modulus



Ultimate Tensile Strength



Results and Market

40-207%

Improvement across test criteria

Out-perform


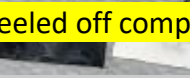
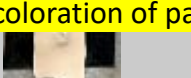
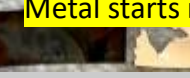


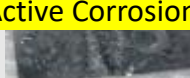





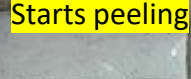










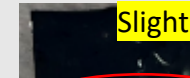
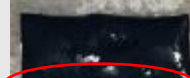

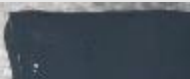




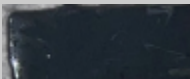
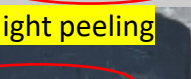



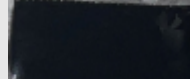
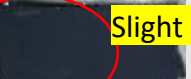


Competitor graphene and CNTs

Performance Materials

Enhanced materials are foundational technology for light-weighting

Application testing underway for improved carbon fiber materials, using CarbenHex®

Corrosion Testing in Acidic Solution

Time/Sample	Day 0	Day 1	Day 2	Day 3	Day 4
Neat		 Peeled off completely	 Discoloration of paint	 Metal starts rusting	
Bare		 Active Corrosion		 Rusting	
CNT					
1%			 Starts peeling		 Peeling
3%			 Dip in paint where X is		
5%	 Not much change			 Slight peeling	
Nabors					
1%			 Slight peeling		 Rust on metal
3%			 Slight peeling		
5%			 Slight peeling		

Observations:

Paint prevents rusting

Nanomaterial prevents paint from coming off.

CNT and Nabors perform similarly at similar loading (likely due to aspect ratio, surface area)

Paint Used: White Dynamics EPO COAT-VA

Nabors Material Used: 03-29-22

Nabors' material is significantly more cost-effective than CNTs

Edge peeling and edge rust is most often due to the sides of the metal not being prepped the same as the surface.

Corrosion Testing in Basic Solution

Observations:

More corrosion, even of neat sample than the acid

The nanomaterial aids in preventing corrosion

The samples are too dark to observe any corrosion therefore it is hard to tell if Nabors outperforms CNT

Nabors' material is significantly more cost-effective than CNTs

Time/Sample	Day 0	Day 1	Day 2	Day 3	Day 4
Neat					
Bare					
CNT					
1%					
3%					
5%					
Nabors					
1%					
3%					
5%					

Too dark to see if there are any black spots but there is not seen corrosion

Too dark to see if there are any black spots but there is not seen corrosion

Edge peeling and edge rust is most often due to the sides of the metal not being prepped the same as the surface.

Corrosion Testing in Neutral Solution

Observations:

The rust on the bare metal came off as it came out of solution.

Day 2 shows the rusted bare in solution compared to out of the solution

CNT seems to outperform Nabors

The evolution of corrosion/rust can also be seen in solution shown below:

Nabors' material is significantly more cost-effective than CNTs

Evolution of Rust Day 4



Time/Sample	Day 0	Day 1	Day 2	Day 3	Day 4
Neat			 Discoloration and corrosion		
Bare		 Rust came off	 In solution		
CNT		 Discoloration starts here		 Staining of the paint	
1%		 Some rust on top of X	 Starts rusting on X		
3%					
5%		 No obvious change			
Nabors		 Starts to rust on edge			
1%					
3%					
5%		 Too dark to see some images			

Edge peeling and edge rust is most often due to the sides of the metal not being prepped the same as the surface.

Lubricants

Testing

Texas A&M and external laboratories have conducted extensive testing with CarbenHex® in lubricants

Value Proposition



Improve Performance at High Temps



Extend Engine Life

Market Segments

Specialty Lubricants

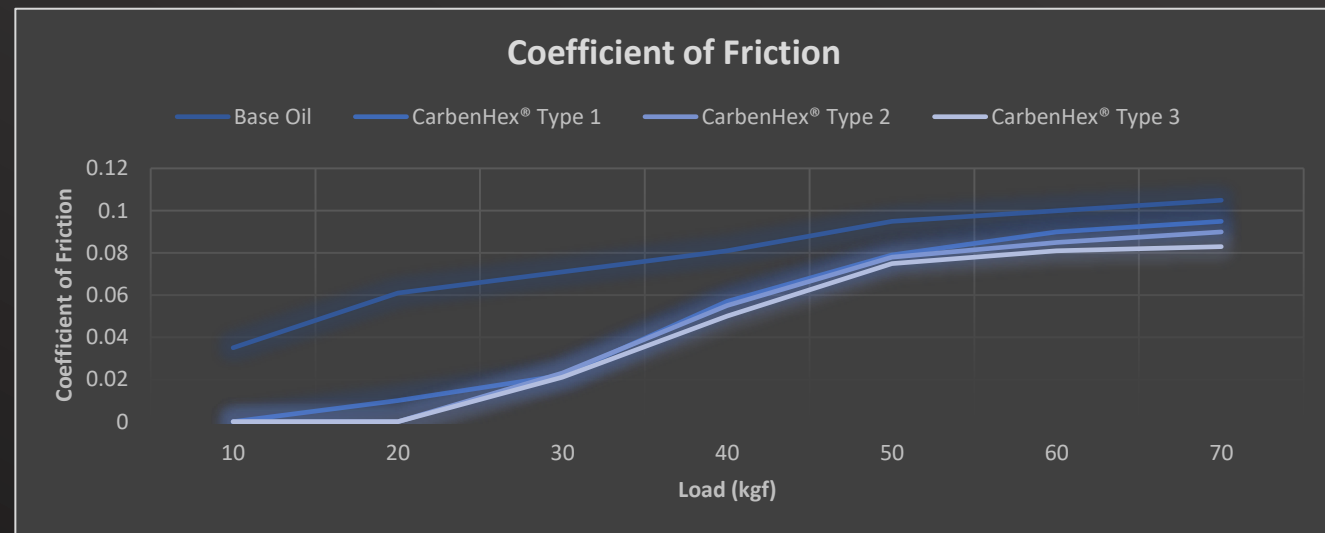
Performance Additives

Bulk Suppliers

Expanded Testing – Texas A&M University

A&M’s Lubricant and Tribology lead, Dr. Liang Hong, will be executing test plan for specialty lubricants for automotive, industrial, and EV technologies

Testing



Results and Market

65-80%

Improved coefficient of friction with graphene

70%

Enhancement of heat transfer rate with graphene

Joint Development

Partner with specialty lubricant manufacturers

Market focused on advanced nanomaterials for performance improvements

DRA Pipeline Additives

Using test loops and dosing units, we can add the correct ration of material to crude at any step of the pipeline

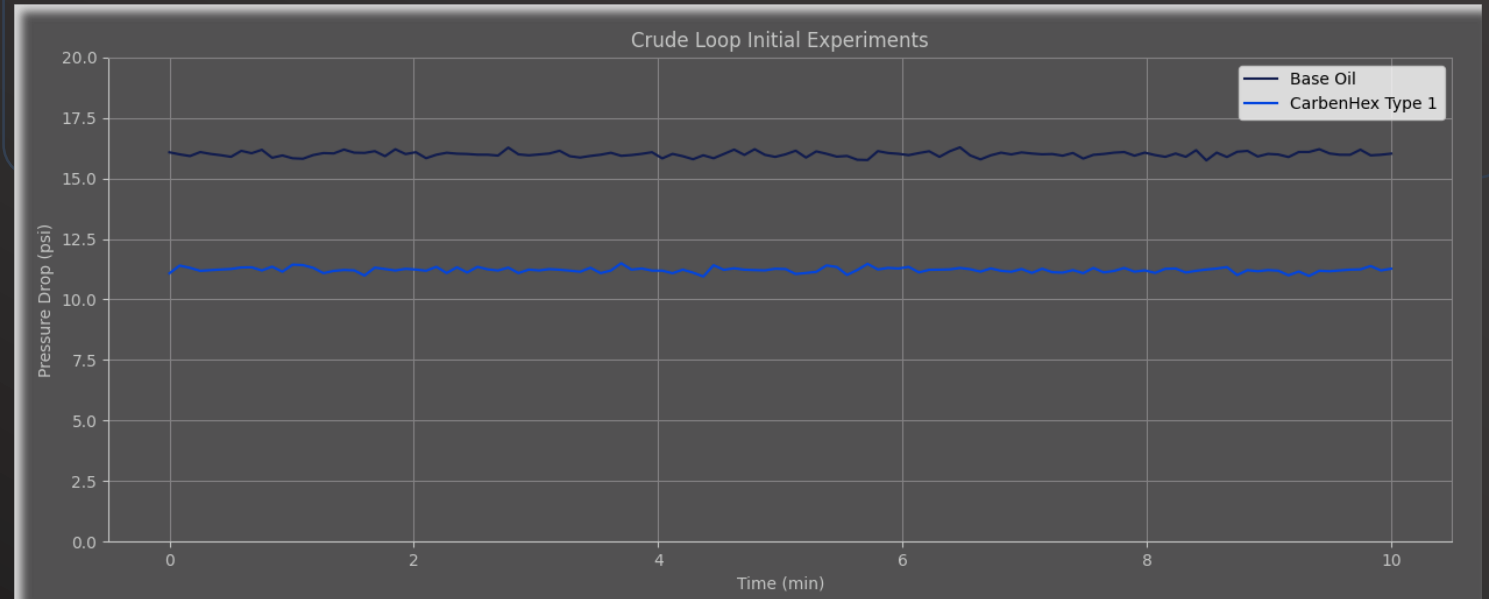
Value Proposition

Less energy needed to move material

Improved life span of pipe, by reducing corrosion



Adding Graphene materials to the crude helps stabilize the flow while at the same time reduce viscosity



Results and Market

Over 35%

Reduced drag coefficient of with graphene

70%

Enhancement of heat transfer rate with graphene

Improved Refined Products

Graphene in the final fuels and lubricants are greatly improved

Market focused on advanced nanomaterials for performance improvements

Coolants

Testing

Texas A&M have conducted extensive testing with CarbenHex® in Ethelene Glycol mixtures, showing improved thermal conductivity

Value Proposition



Improve Performance at High Temps



Reduces energy consumption needs

Market Segments

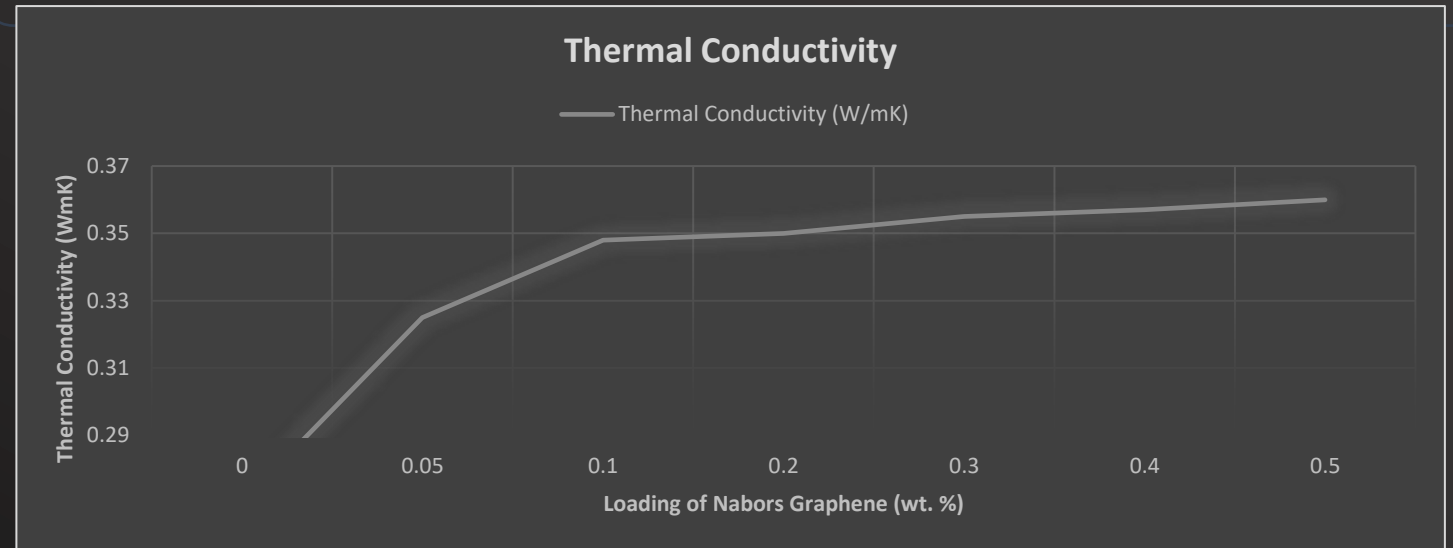
Automotive coolants

Performance Additives

Antifreeze

Testing – Texas A&M University

Dr. Green’s group at Texas A&M University combined Nabors graphene at various loadings with 50/50 water/Ethelene Glycol mix to conduct Thermal Conductivity testing



Results and Market

16.7%

Improved Thermal Conductivity at .1% loading

\$4.6B

Automotive coolant market in 2021

Market Need

Cooler engines run more efficiently, reducing the overall power need

Market is focused on advanced nanomaterials for performance improvements

Conductive Inks

Testing

Texas A&M conducted testing with CarbonHex® ink versus market products

Value Proposition



Increased Conductivity



Advanced displays and "Smart" surfaces

Applications

Printed electronics and displays

Advanced touchscreen performance

"Smart" sensors and coatings

2.5X

Improvement of commercial conductive inks/paints

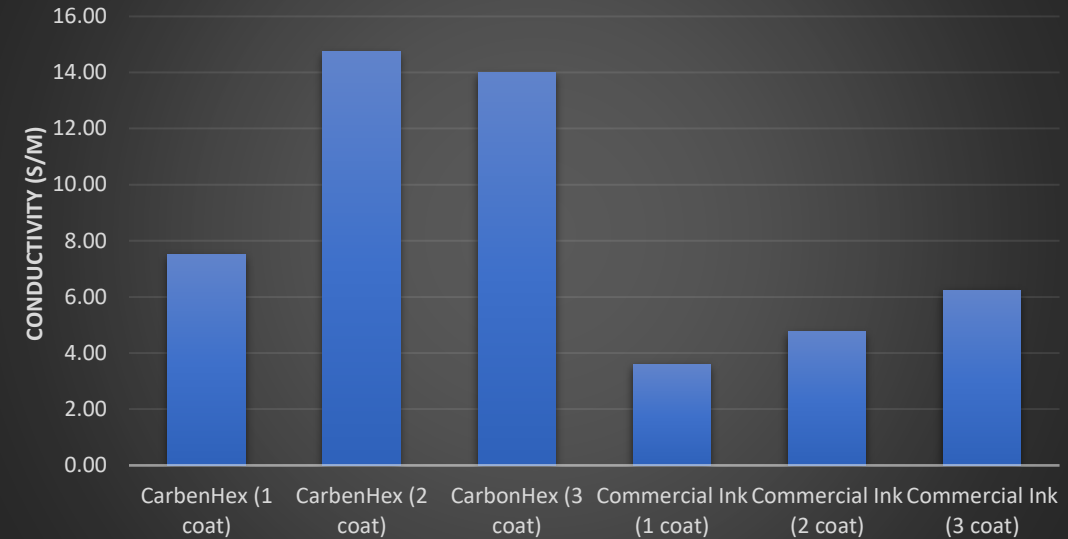
50%

Thickness reduction, allowing advanced applications

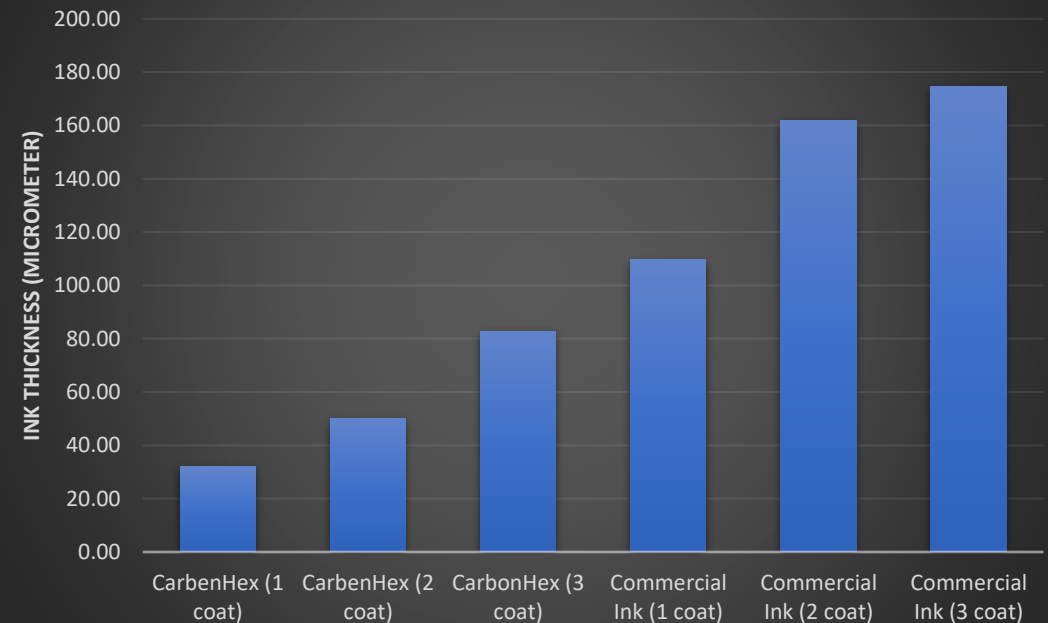
Market

Finishing product development to test with Manufacturer, who makes touchscreens and printed electronics

Ink Conductivity



Ink Thickness



Concrete

Testing

220+ Concrete varieties have been tested to ASTM standards, with direction from Texas A&M

Value Proposition



Improve Strength, Flexibility

Performance Trends

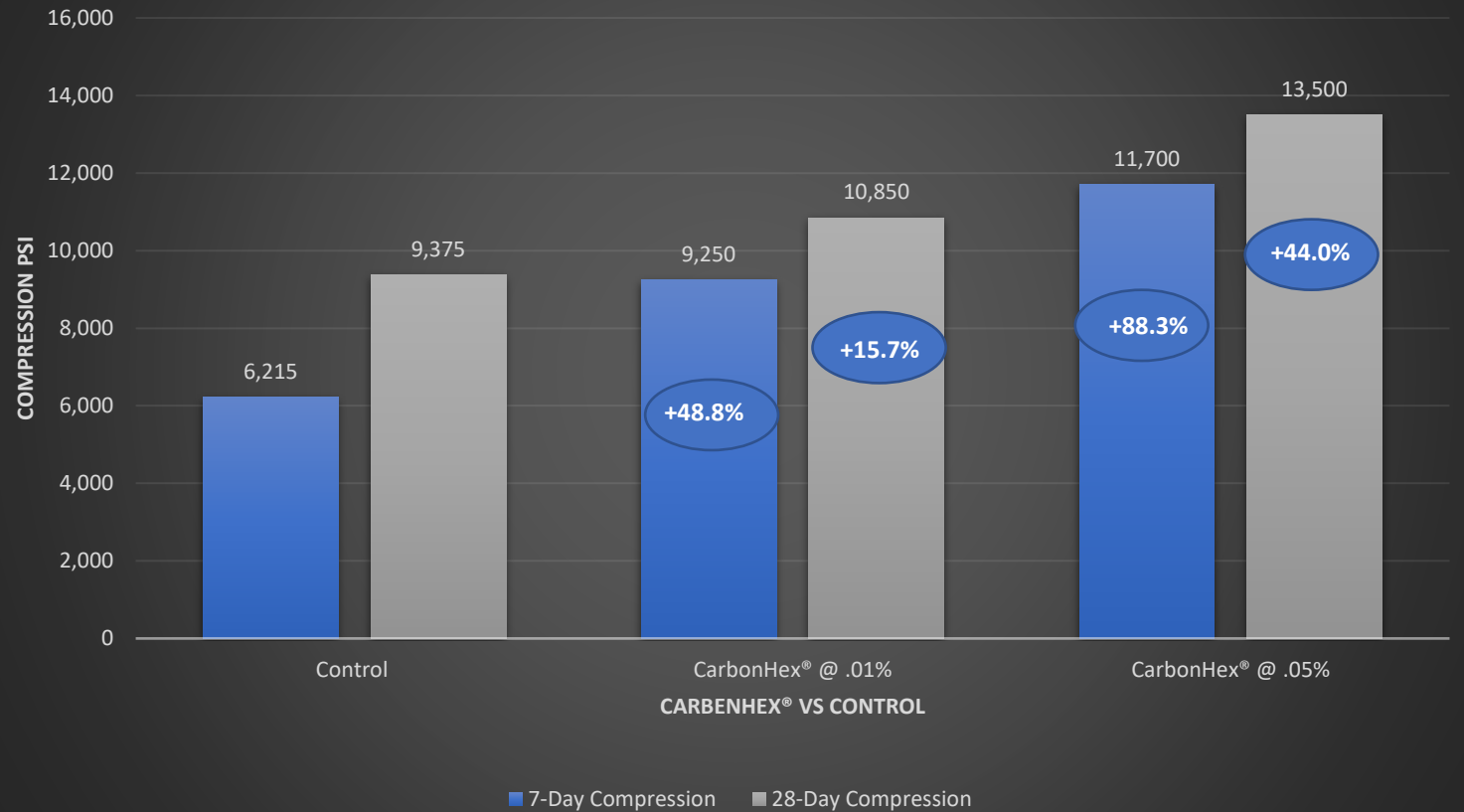
Significant 7 & 28 day improvement

Graphene content .01-.05% of Cement

No effect on slump or workability

Up to 30% cement reduction possible

Concrete vs CarbenHex(R) Concrete



Economics

Cement Reduction

Reduced material costs

Performance Applications

Meet high performance design specs

Carbon offset credits

Development pathway to suit requirements

Green project qualification

Regulations are trending towards stricter material requirements

Hydrogen

Total Market Size

\$130 Billion (2021)

Value Proposition



Lower Costs



Increase Durability

Applications

Electrolysis / Fuel Cells

PEM Membranes

Fuel Enhancement/Injection

Hydride Energy Storage

PROBLEM

Hydrogen production needs to grow 5,500+% to reach net zero by 2050 but costs of enabling technologies (fuel cells, electrolyzers) are deeply constraining

SOLUTION

Graphene enhanced fuel cell and electrolyzer technologies increase efficiency over 90% and reduces cost over 95%

KEY STATS

\$53.4B

Size of electrolyzer market by 2030

50%

of the capital cost of PEM electrolyzers are rare earth materials

**Fuel Cell
39kWh/kg**

Patented loading and production technology.

**Electrolyzer
42kWh/kg**

Patented Ionomer membrane with graphene-based catalyst.

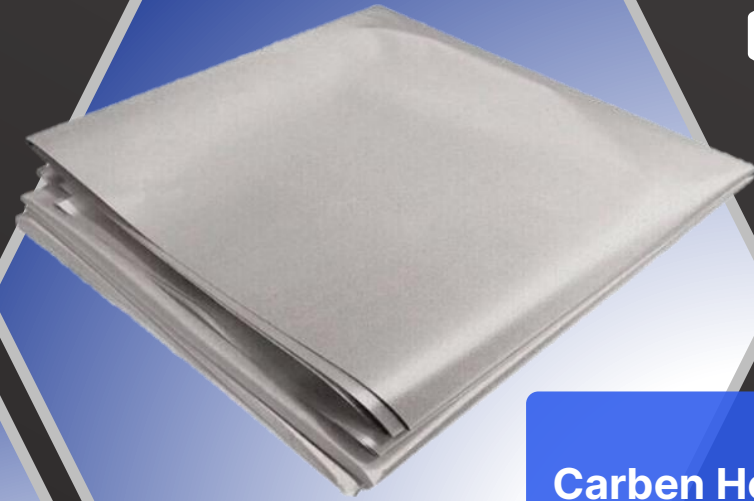


Carben Hex incorporated into stealth materials for added strength, and reduced radar signatures.

Currently testing at A&M in their Anechoic Chamber recording the absorption of the radar frequency range.



Military applications for Carben Hex



Carben Hex incorporated into Faraday cloths or coatings and material may shield buildings and equipment from EMP



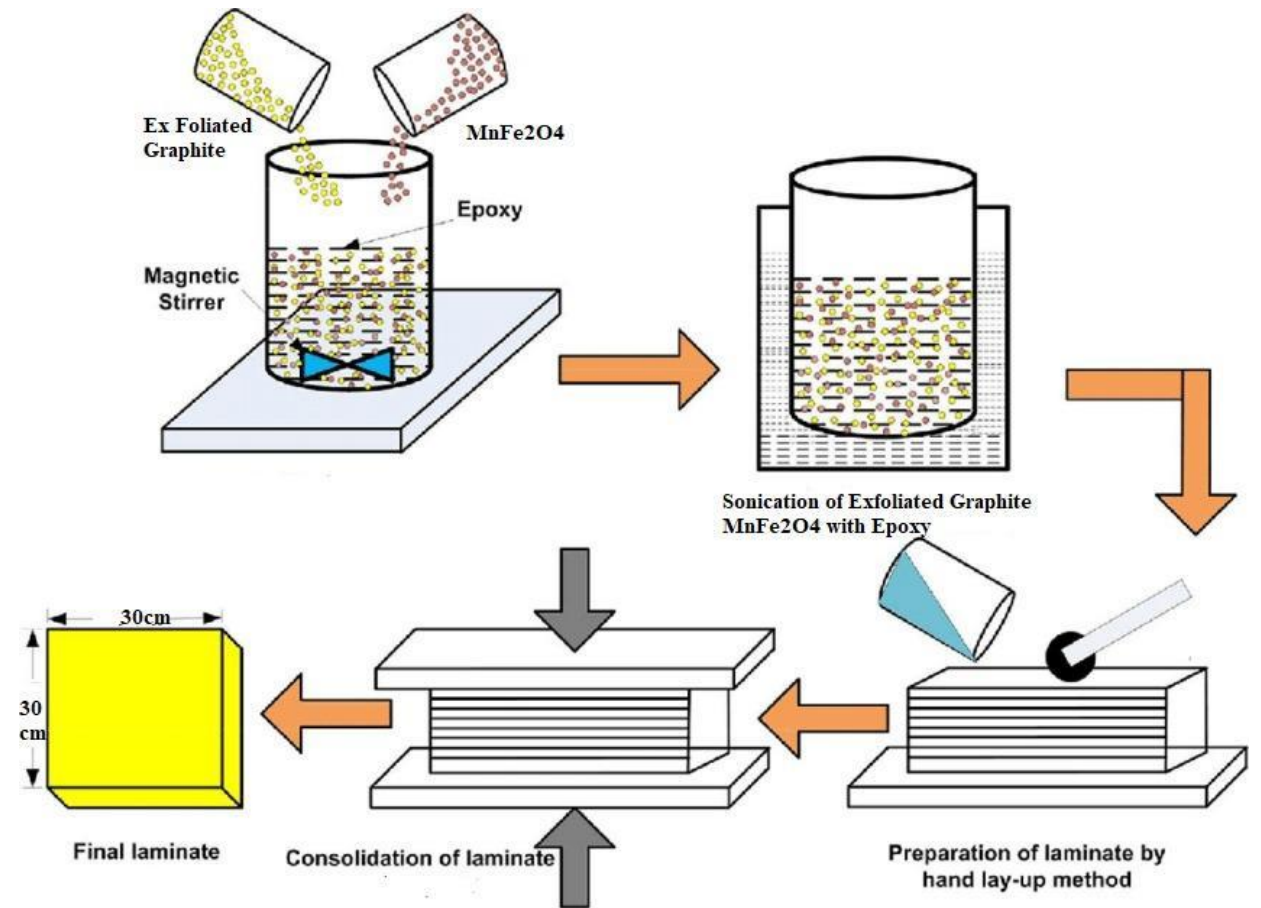
Electromagnetic pulses are generated by from detonations or solar flares



CONFIDENTIAL

Prior work on Radar absorbing materials (RAMs)

- Pratylya: We created an epoxy composite by adding **Manganese Hexaferrite (MnFe_2O_4)** nanoparticles and **Exfoliated Graphite** nanoparticles to **epoxy** and then reinforced the composite with layers of **carbon fiber mats**.
- The composite was created using a hand lay up method.
- We had created 5 samples of varying concentration of nanofillers.



New Materials for structural performance

Ballistics Solutions

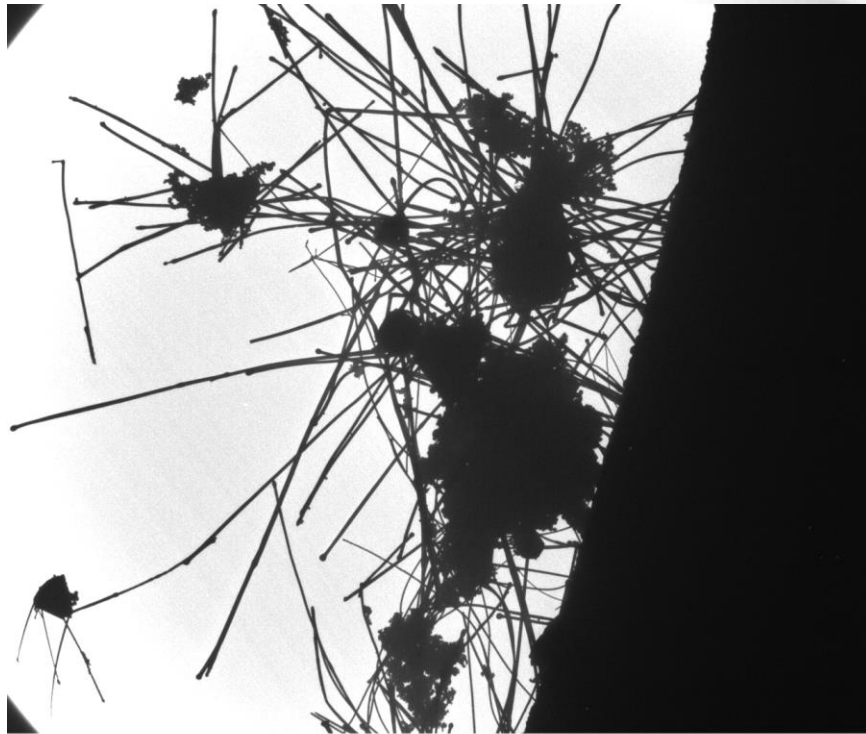
- Silicon Carbide, Nanotubes, Tungsten Carbide
- Titanium Carbide
- Structural Graphene
- Tungsten Carbide



Better Energy Dispersion and Absorption
Minimal body damage
60-80% lighter
50% Thinner
Higher Flexibility
Ability to apply to existing armor plating
Cost Effective

Silicon Carbide

384.8 nm



5 μ m
LVEM25

FOV 55935 nm

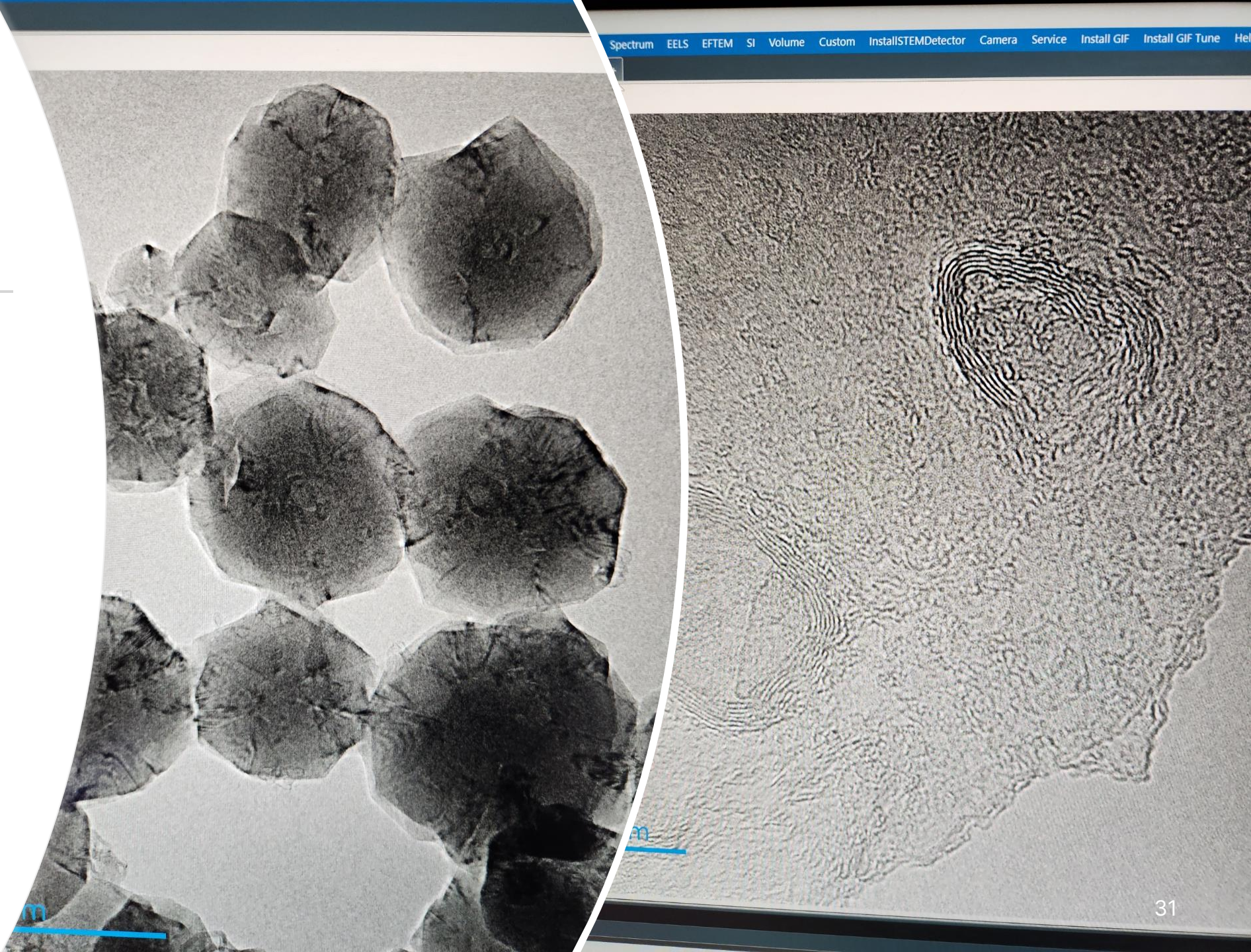
det	curr	WD	mag	<input type="checkbox"/>
ETD	73 pA	5.0 mm	100 000 x	

2 μ m

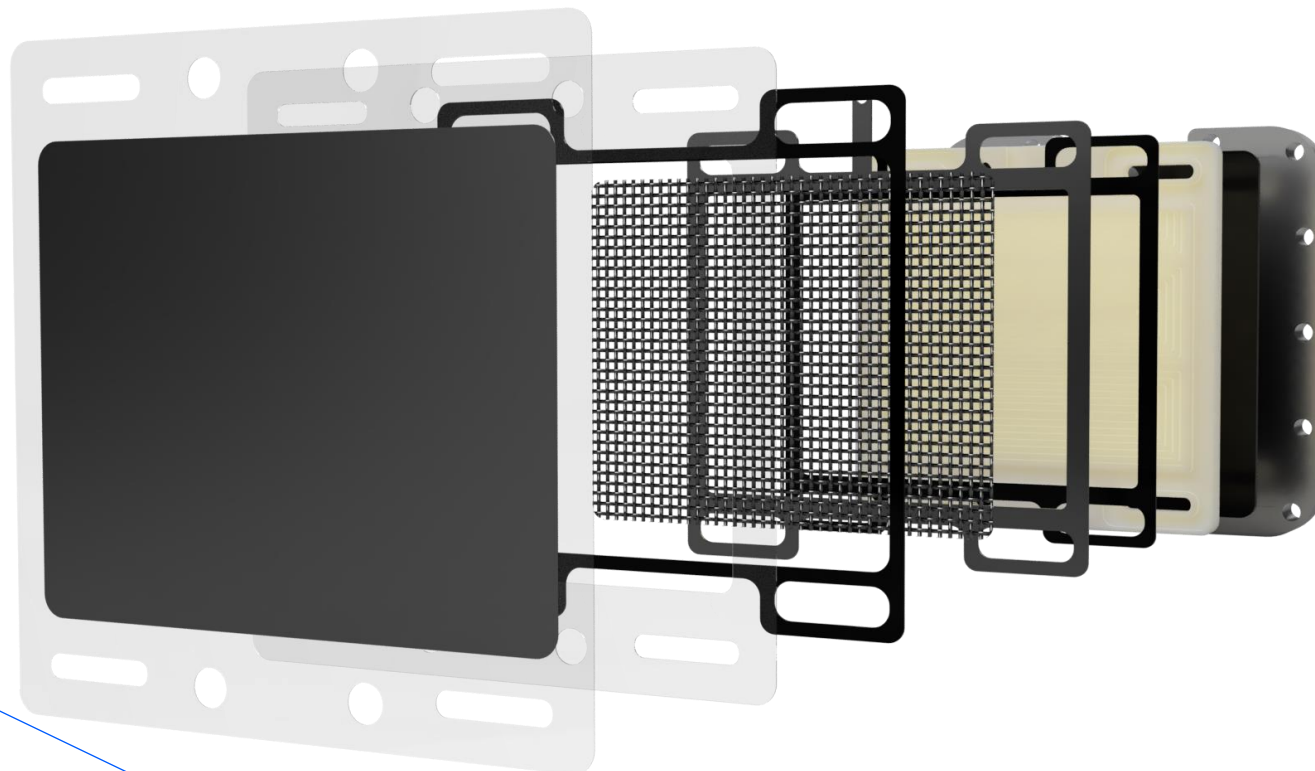
30

Houston Electron Microscopy

Carbon Nano Onions



Fuel Cell Stack



Membrane:

- Specialized Ionomer Material
- Carbon Nano sub-structure with enhanced proton exchange
- Low Cost (95% cheaper than Nafion)

Catalyst:

- Unique Carbon Nano Structure (high surface area)

Current Collector:

- Carbon Nano Coating

High Durability

High Efficiency (over 80% round trip)

Low Cost/Scalable

Low environmental Impact

Hydrogen

Value Proposition

Proprietary fuel cell and electrolyzer products based on our nano technologies will yield leading performance stats and substantial capital cost reductions.

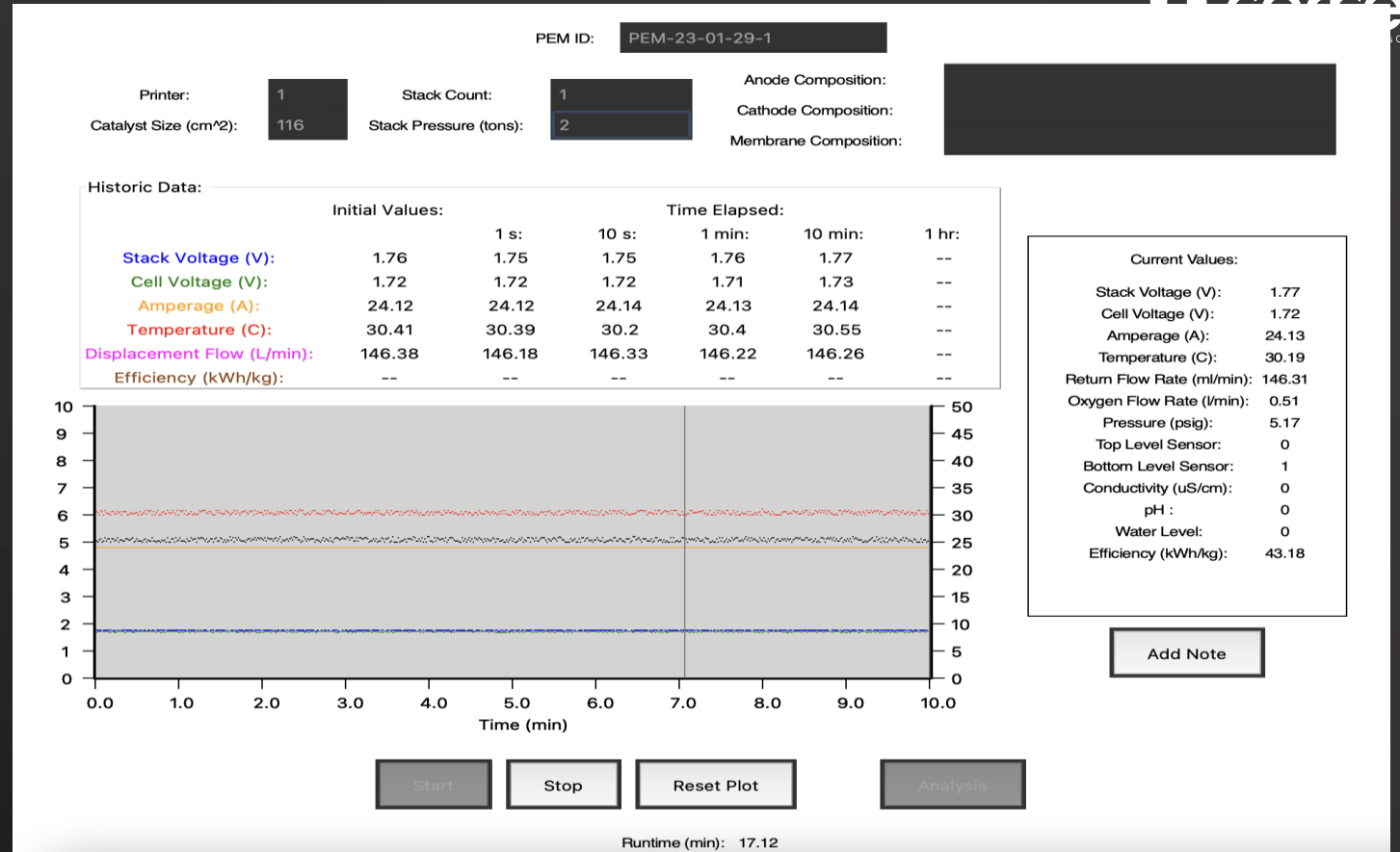
Applications

Electrolysis / Fuel Cells

PEM Membranes

Fuel Enhancement/Injection

Hydride Energy Storage



KEY STATS

\$53.4B

Size of electrolyzer market by 2030

50%

of the capital cost of PEM electrolyzers are rare earth materials

**Fuel Cell
39kWh/kg**

Patented loading and production technology.

**Electrolyzer
42-45kWh/kg**

Patented Ionomer membrane with graphene-based catalyst.

Hydrogen Powerwall



Low-Cost Scalable Power Solutions

Long life span

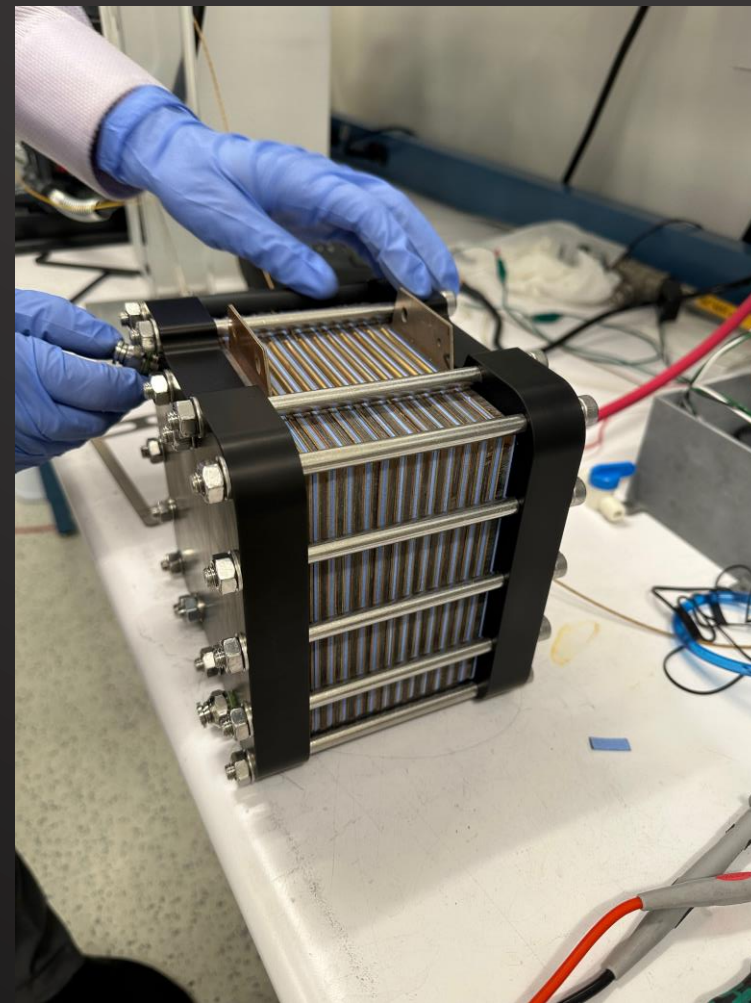
Easy maintenance

Add more power or energy storage later

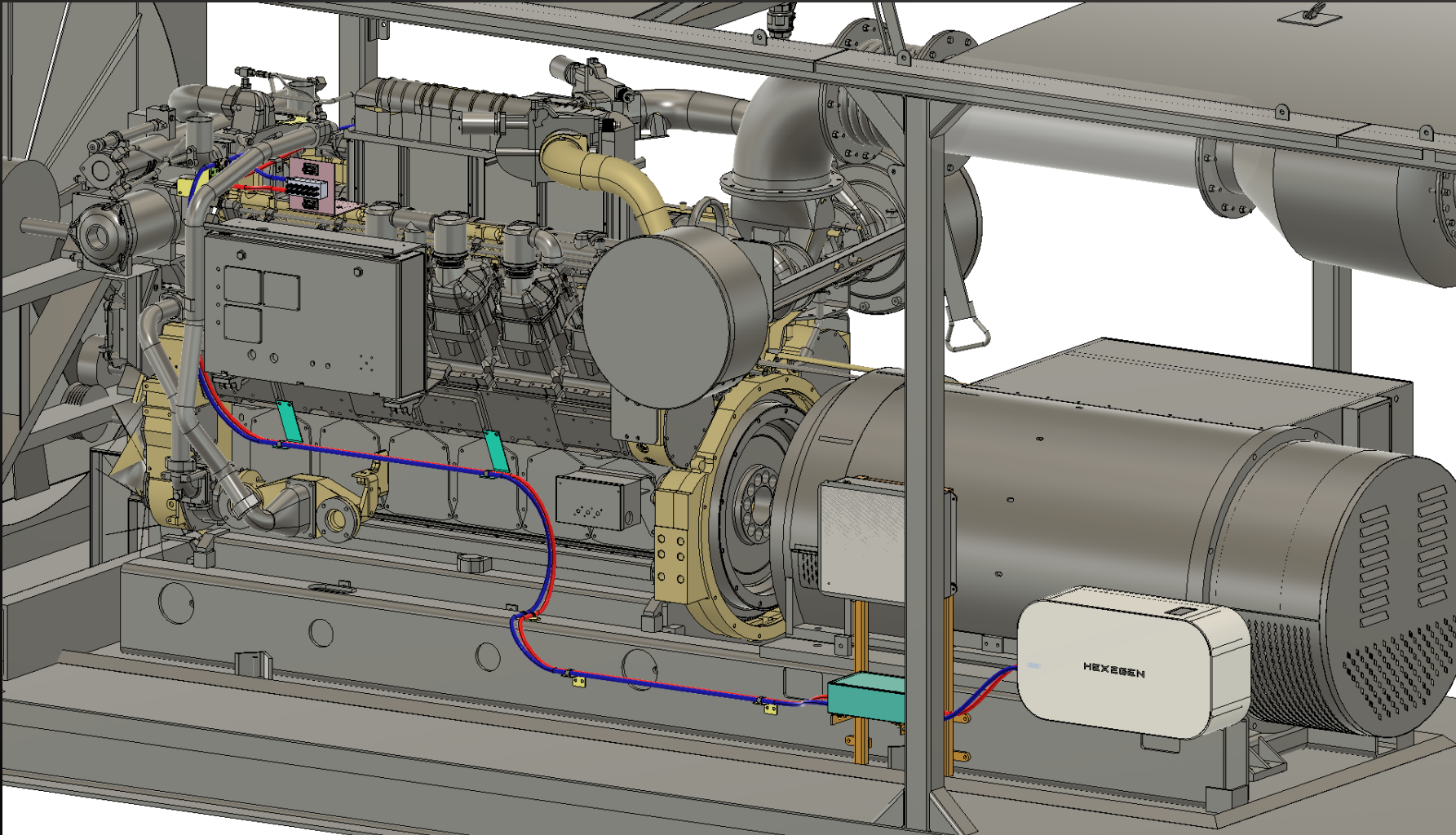
Low pressure for safety and efficiency

Plug and Play design for any hydrogen source

HIC Electrolyzer



HIC Rig 3512



HIC-DD13 install



4KG Hydrogen Electrolyzer

Low-Cost Scalable Power Solutions

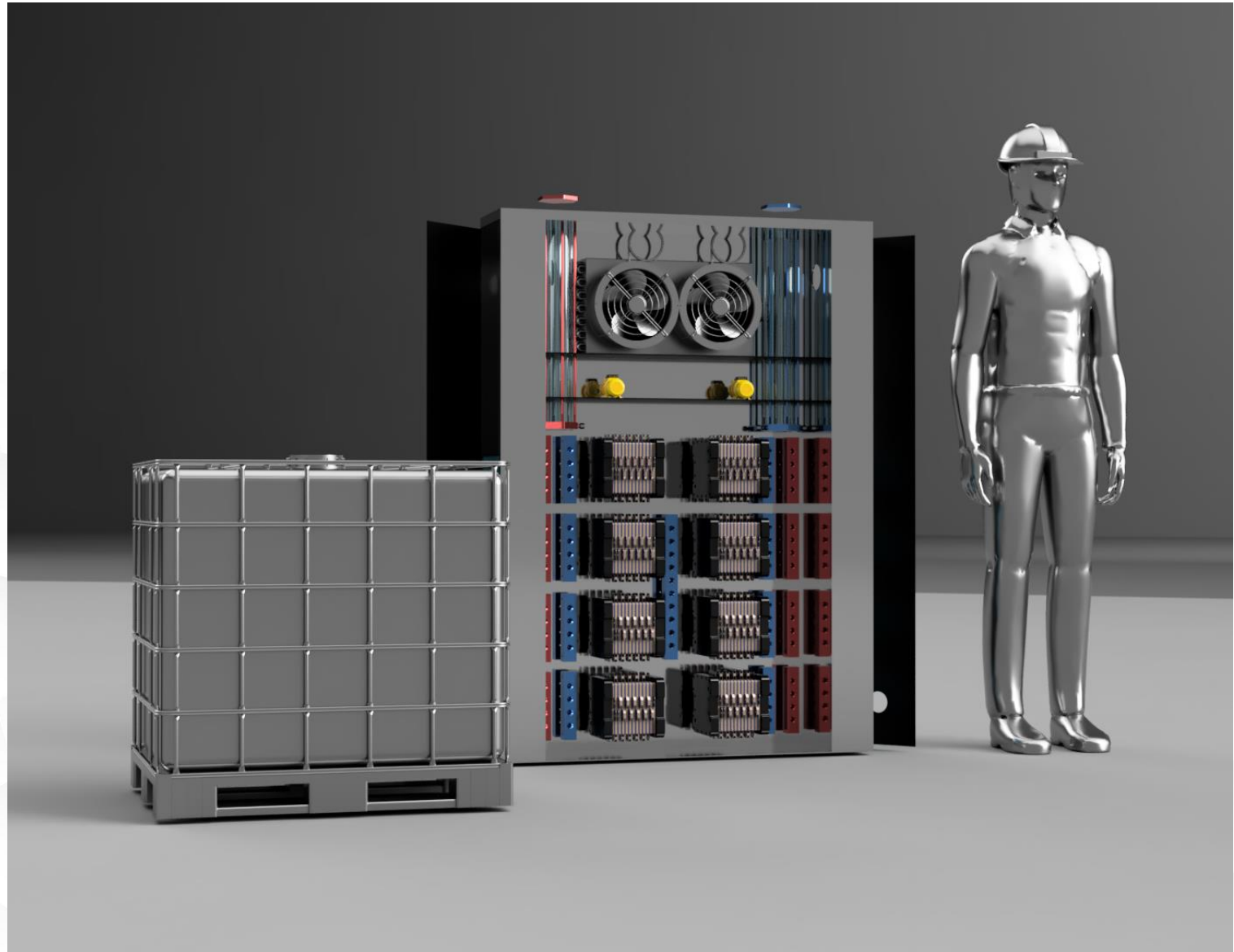
Long life span

Easy maintenance

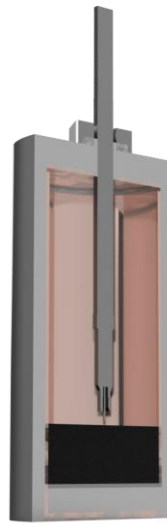
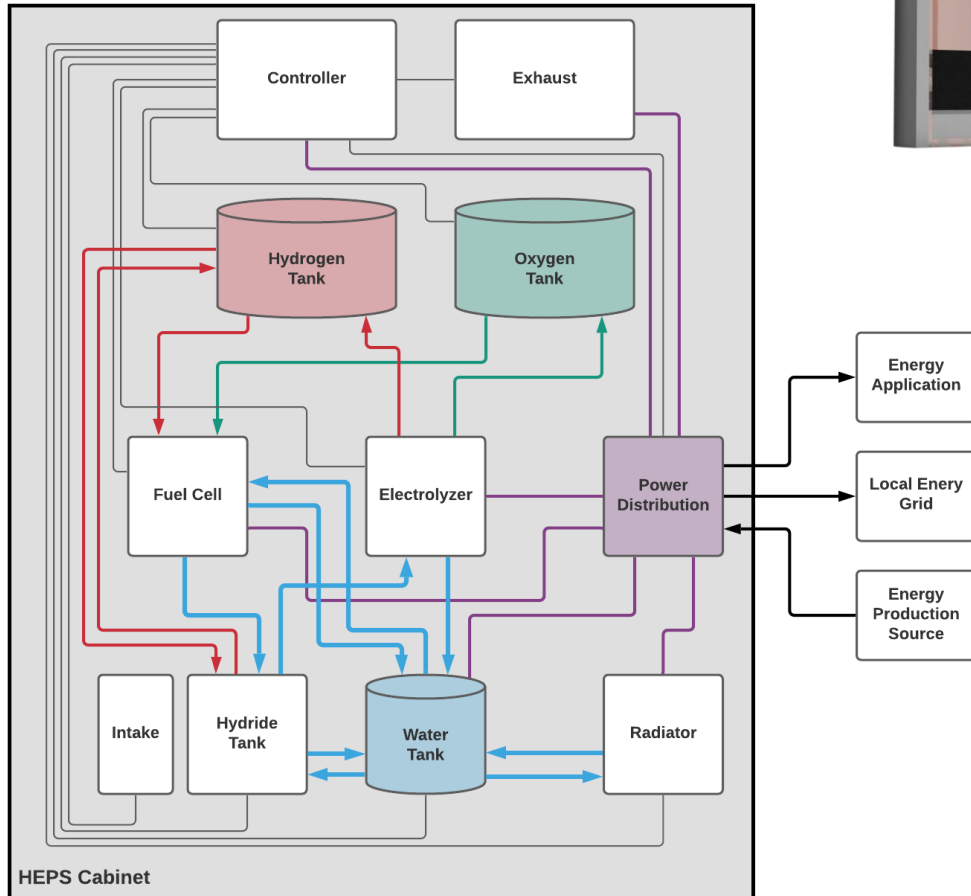
Add more power or energy storage later

Low pressure for safety and efficiency

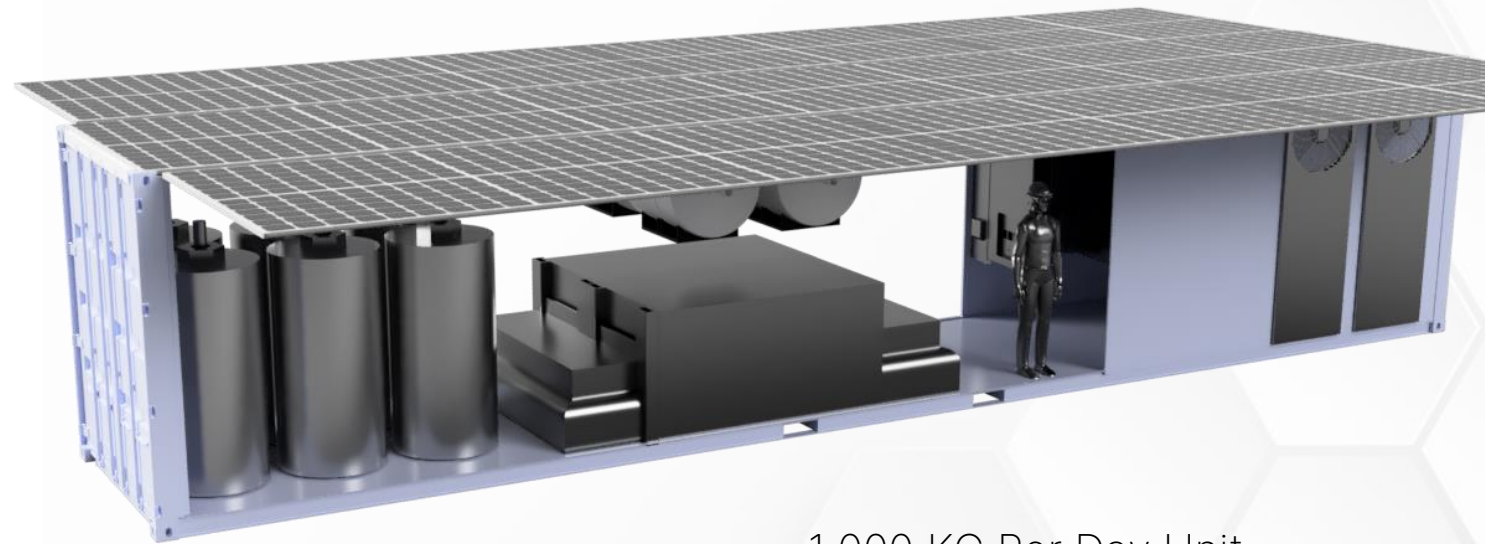
Plug and Play design for any hydrogen source



Hydrogen Energy Production and Storage (HEPS) System

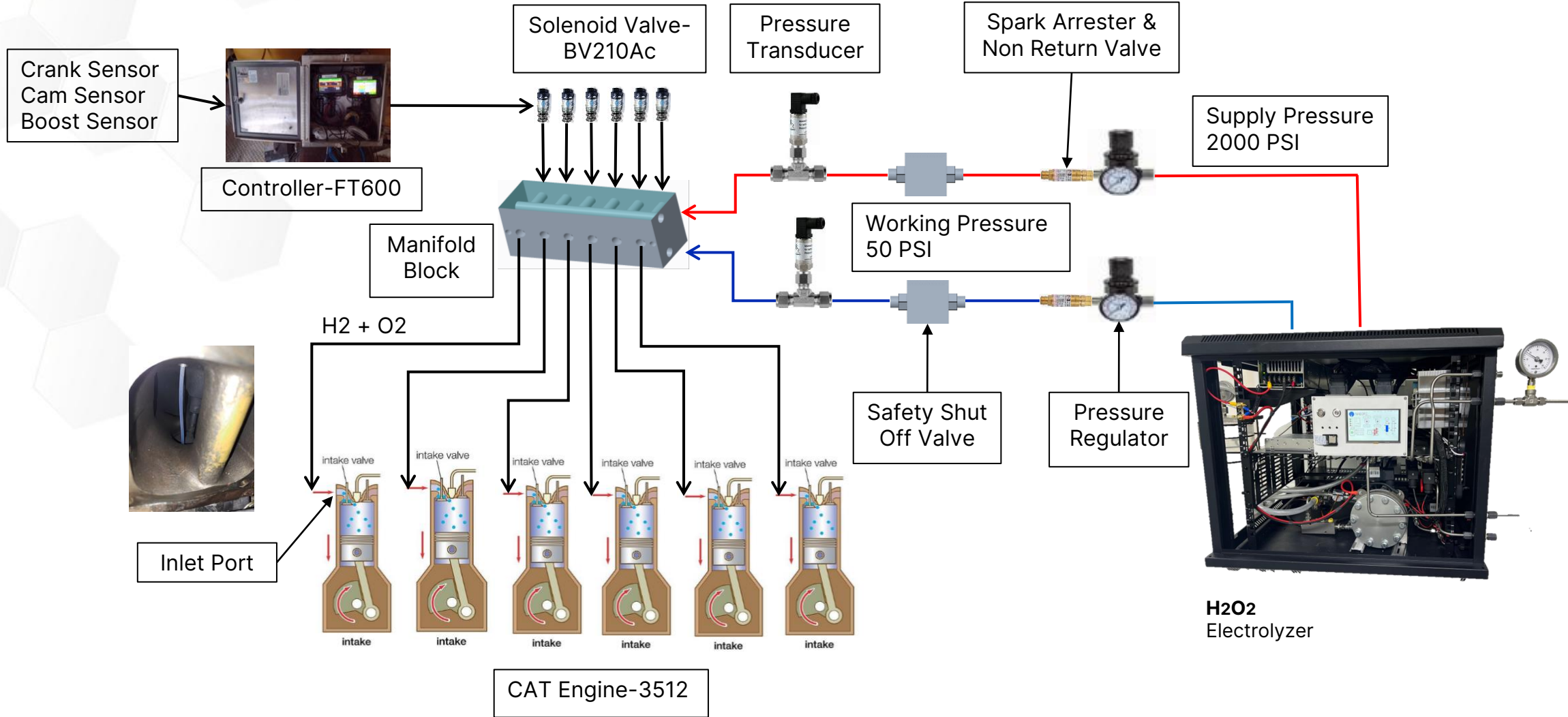


- The union of cutting-edge membrane technology
- Groundbreaking advances in hydrogen Storage using carbon nano hydrides.
- The HEPS System is modular, scalable, efficient, safe and cost effective

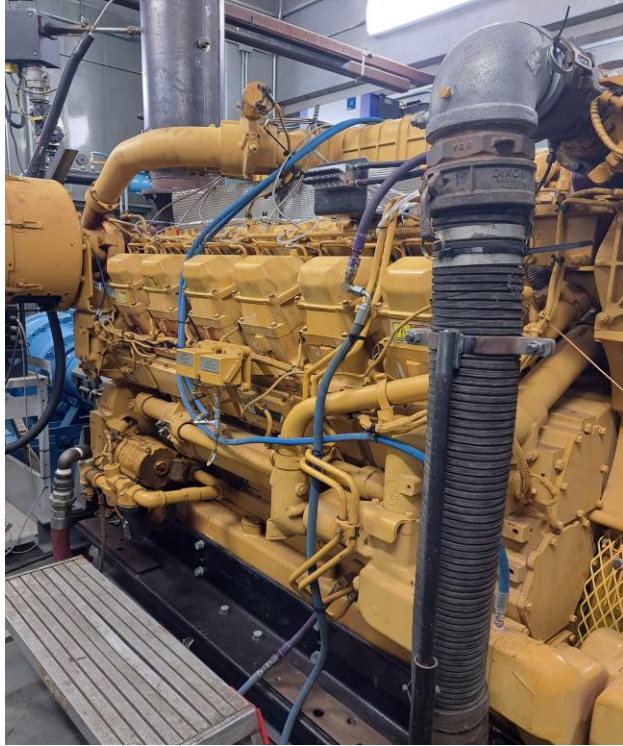


- 1,000 KG Per Day Unit
- 5,000 KG of Hydride Storage
- 25-year life span

HIC Gas System Schematic from Nabors



HIC Hardware installed on 3512 engine





CARBEN-TECH.COM

NABORS CORPORATE SERVICES

515 W. Greens Road
Suite 1200
Houston, TX 77067-4525