



AURORA HYDROGEN



Summary

- Developing low-cost, distributed hydrogen production technology
- The hydrogen market is expected to grow to over \$2.5 trillion by 2050
- Existing hydrogen technology is either high cost, high emission, or highly centralized
- Aurora's technology uses microwave energy to efficiently convert methane to hydrogen and solid carbon with no CO₂ generation
 - Both modular and scalable, requires no new pipelines
 - Lowest projected cost of any hydrogen production method
 - 80% less electricity and lower overall GHG impact than water electrolysis
 - No plasma and no catalyst, produces pure elemental carbon
- Founding team has deep technical expertise and proven industrial tech scale-up, commercialization, and sales experience
- Producing hydrogen continuously at the bench scale (TRL 5), patent pending
- Already raised +\$1MM from strategic industry partners and government matching
- Raising \$10MM (Q1/Q2) to fund 200 kg-H₂/day demonstration plant (early 2023)

Company Purpose

To lead the global transition to a net-zero economy by developing low-cost, distributed hydrogen production technology.

Market Opportunity

The global hydrogen market is expected to grow **10x by 2050.**

What is the value of hydrogen?

High volume (industrial): \$2.00/kg

Low volume (transportation): +\$3.50/kg

\$50 Billion

1980: 25MT/yr

\$190 Billion

2020: 90MT/yr

+\$2.5 Trillion

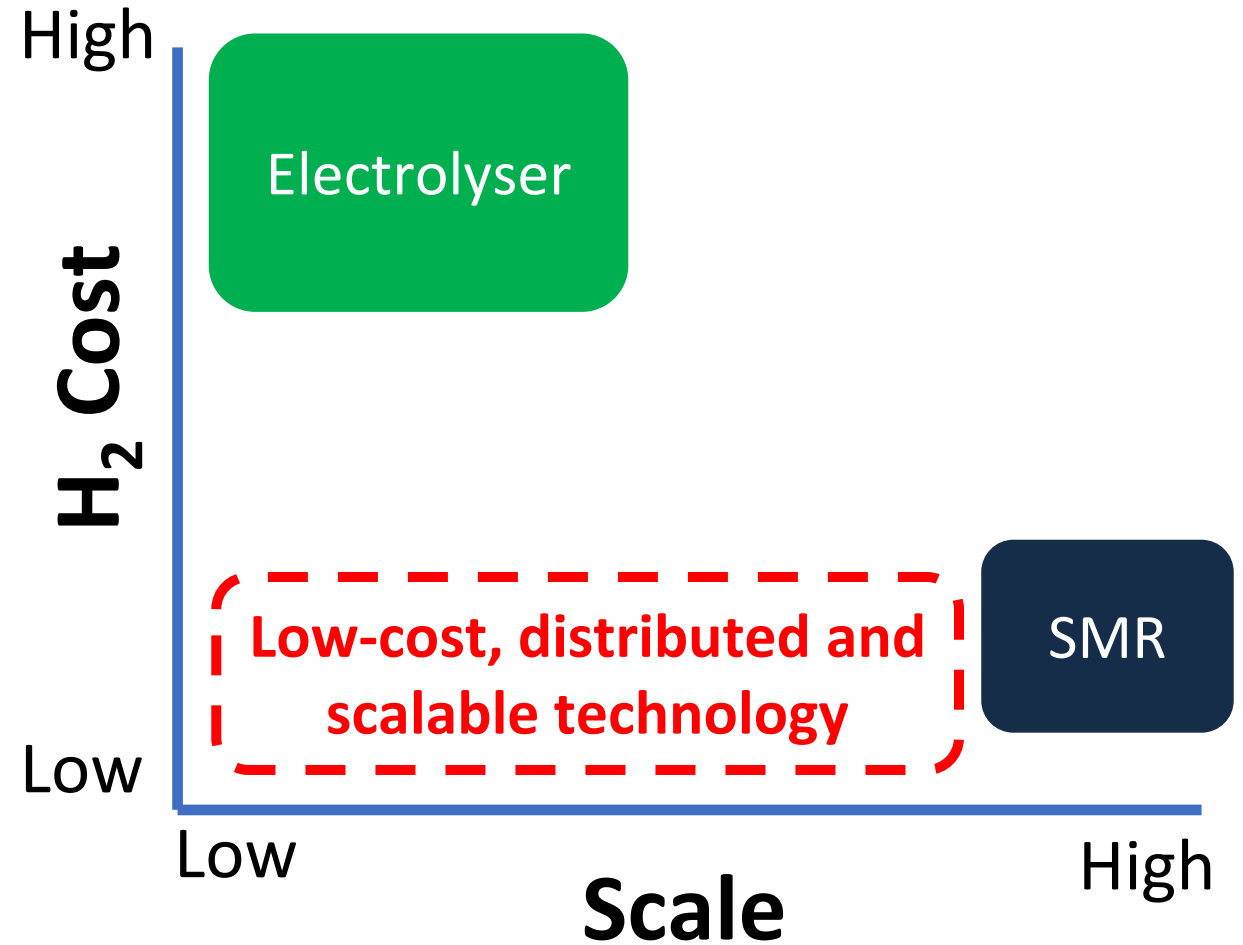
2050: +700MT/yr

- + Natural gas blending
- + Heavy-haul fueling
- + Municipal use
- + Steelmaking
- + Biofuel production
- + Energy storage

The Problem

Low-cost, distributed hydrogen production does not exist but is required to enable new use cases

- Steam methane reforming (SMR) is low-cost but **centralized**, requiring costly transportation
- Electrolysers are modular, but require large amounts of electricity and are **high cost**



The Solution



Turquoise Hydrogen

- Natural gas + electricity
- Low electricity demand
- No CO₂ generation
- Low cost
- Two unique benefits
 - Hydrogen production
 - Convert natural gas to a clean, high-value fuel

Aurora's Technology

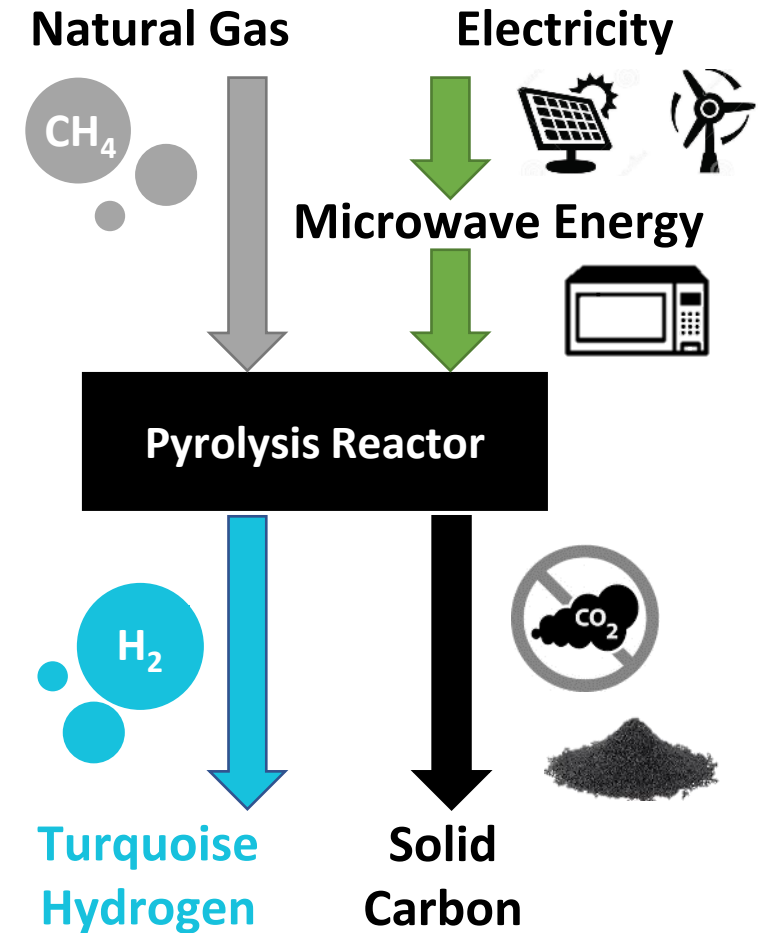
- **Lowest electricity of any turquoise hydrogen**
- **Lowest cost of any hydrogen production**
- **Lower GHG impact than green hydrogen in most regions**

Technology Overview

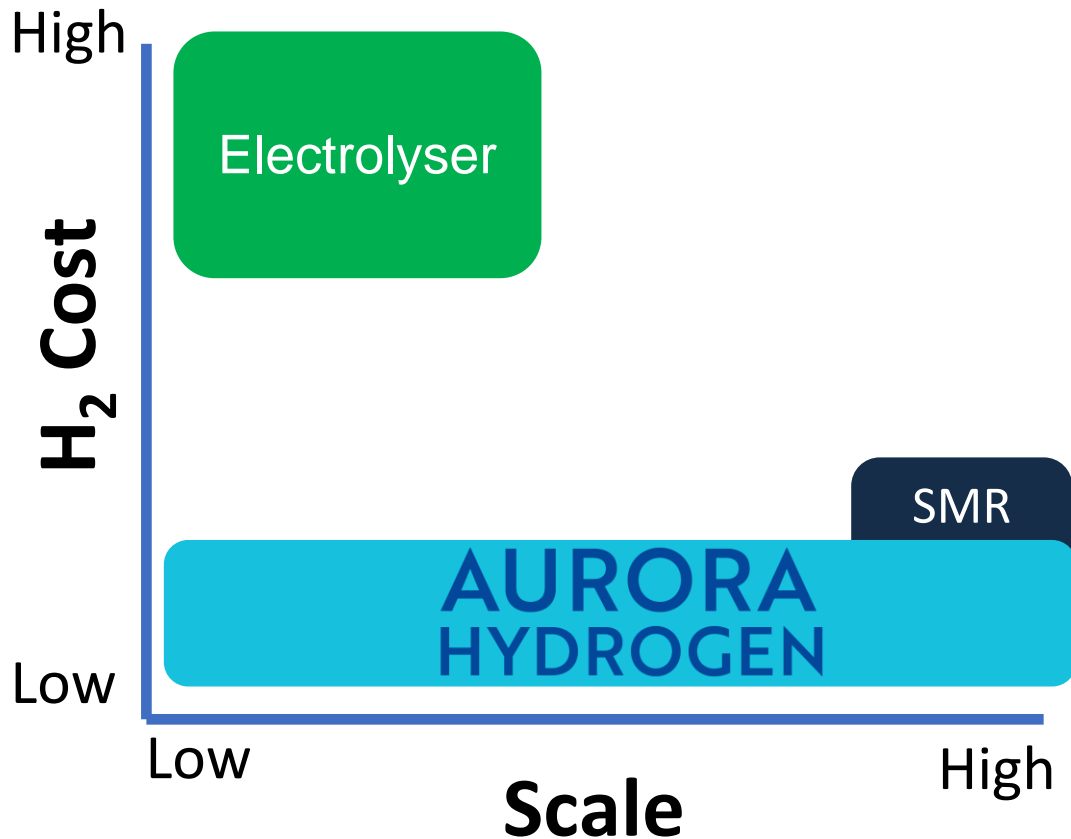
- A unique and novel approach combining
 - Methane pyrolysis expertise
 - Microwave and materials expertise
- We produce H₂ from natural gas with no CO₂ generation:



- We are **NOT**:
 - Using a plasma
 - Using a catalyst
- We are:
 - Using efficient microwave energy
 - Directly heating the carbon product




Technology Overview



- Highly scalable and modular units:
 - ↳ Hydrogen produced where needed
 - ↳ No new pipelines required (H₂ or CO₂)
 - ↳ No water required
 - ↳ Fast startup and shutdown for renewables
 - ↳ 80% less electricity than Green Hydrogen
- Patent pending for core process
 - ↳ Preliminary examination stated, “all of the claims are novel and inventive.”
 - ↳ Additional IP expected in reactor and process design

Competitive Advantage

Technology	Developers / Operators	H ₂ Type	Op Cost* (\$/kg-H ₂)	Electricity (MJ/kg-H ₂)	Intermittent Operation	Products	Emissions (kg-CO ₂ /kg-H ₂)	Scalable	Modular	New Pipelines
Microwave Pyrolysis	 AURORA HYDROGEN	Turquoise	\$0.67-1.25	35	Yes	H ₂ + pure solid carbon	No direct emissions	Yes	Yes	None required
Molten Metal Pyrolysis	UCSB Czero (developing)	Turquoise	\$0.76-1.62	52	No	H ₂ + impure solid carbon	No direct emissions	Yes	No	H ₂
Plasma Arc Pyrolysis	Monolith (operating)	Turquoise	\$1.18-3.32	120	Yes	H ₂ + pure solid carbon	No direct emissions	No	Yes	H ₂
Electrolysis of Water	Hydrogenics, (operating)	Green	\$3.13-8.50	193	Yes	H ₂ + O ₂	No direct emissions	Yes	Yes	None required
Steam methane reforming	Air Products (operating)	Grey	\$1.25-2.25	-	No	H ₂ + CO ₂	9	Yes	No	H ₂
Steam methane reforming + carbon capture & storage	Air Products (developing)	Blue	\$1.44-2.69	-	No	H ₂ + CO ₂	1	Yes	No	H ₂ and CO ₂

*Assumes average natural gas price in Alberta last 5 years (\$1.79/GJ hhv), renewable electricity cost \$20-80/MWh, and carbon price of \$40/t CO₂e, all CAD

Company Status

Technology


- Continuous hydrogen production at bench-scale
- $\text{CH}_4 \rightarrow \text{H}_2$ model verified
- 1 kg- H_2 /day & **TRL 5**
- **Ready to scale up**
 - ATCO hydrogen blending site confirmed for demonstration



Funding

- \$1.3MM non-dilutive raised for bench-scale development
 - 4 industry partners
 - Government matching
- **Seeking funding for scale-up**
 - Demonstration Plant (\$10MM)
 - Leverage non-dilutive government funding
 - Targeting \$10MM equity now + \$10MM non-dilutive to follow for commercialization

Technology Development Roadmap

Activity					
	Bench-Scale Production	Demo Plant v1.0	Demo Plant v2.0	Demo Plant v2.1	Scale Up
Production Rate	1kg-H ₂ /day		185kg-H ₂ /day		+1,850kg-H ₂ /day
Power	1kW @ 2,450MHz		75kW @ 915MHz		750kW @ 915MHz
Hydrogen Production	Continuous				
Carbon Handling	Batch		Continuous		
Ancillary Equipment	-	Heat exchanger	Particle separator	All ancillary equipment	
Risk Mitigated	Prove continuous hydrogen production	Combined MW reactor 2450 → 915 MHz	Carbon handling	Transition to field operation	Industrial-scale operation
Outcome	Conceptual reactor designs for pilot plant	Prove energy efficiency	Reactor design selected for field testing	Proof of technology in operating environment	Scale up proven
Technology Readiness Level (TRL)	5	5	6	7-10	8-10
Achieved By	Oct 2021	Jan 2023	Apr 2023	Jul 2023	Oct-Dec 2023
Cost (Hardware + Burn)	\$1.3MM	\$3-4MM	\$2-3MM	\$3-4MM	\$7-10MM

Commercialization Strategy

Phase 1: Existing Market Opportunity

Strategy: **focus on existing H₂ markets** and customers, don't rely on meeting emerging/non-existent markets.

Replace grey H₂ in Alberta

- 1,300t H₂/day = **\$1B/year**

Natural gas blending in Canada

- 4,500t H₂/day = **\$3B/year**

Phase 2: New Market Development

Strategy: leverage **low-cost, distributed production** to develop new markets to 2050 via production, equipment sales & licensing.

- Global natural gas decarbonization
Leveraging Canadian references
- Industrial feedstock
Steelmaking, chemical production
- Transportation
Highest potential value
- Energy storage
Renewable electricity load levelling

Key Risks & Mitigation Strategies

Risk	Type	Mitigation
Domestic (2,450MHz) to industrial (915MHz) microwave power transition / prove energy efficiency	Technical	Trial with batch-mode v1 pilot reactor. Leverage Bobicki & Gillis experience doing same in a mining application
Continuous carbon removal from reactor	Technical	Generate 6+ design concepts and trial 3+ at the demo scale to select commercial design.
Laboratory-to-field transition	Technical	Trial all components in a controlled/laboratory setting before field demonstration
Scale-up to commercial H2 production	Technical	Utilize all same componentry from pilot-scale at larger capacity. Same microwave frequency.
Potential hydrogen markets fail to develop	Market	Focus on existing markets in initial commercialization phase
Dramatic increase in natural gas prices	Market	Focus on regions with high electricity prices and high carbon performance credits
Regulatory framework undeveloped for carbon performance credits via solid carbon	Regulatory	Develop high volume outlets for Aurora's elemental, granular solid carbon product (steelmaking, soil amendment, graphene production)
Unable to hire key personnel in local market	Organizational	Maintain remote work/work-from-home practices and routines to enable remote hiring
Unable to hire and onboard to meet technology development schedule	Organizational	Rely on contractors for non-core activities (e.g., accounting, admin, routine engineering tasks, industry-standard pilot plant components)

Founding Team



Andrew Gillis, MBA, P.Eng

- **President & CEO**
- 10+ yrs in industrial technology development, commercialization, sales & marketing
- VP-level experience at a large mining equipment manufacturer



Erin Bobicki, PhD, P.Eng

- **VP & Technical Director**
- Professor at UofA
- 10+ years in novel applications of industrial microwave energy
- Leads an industry consortium to scale-up microwave technology for the mining industry



Murray Thomson, PhD, P.Eng

- **VP & Technical Director**
- Professor at UofT
- 20+ yrs in high temperature pyrolysis of hydrocarbon fuels
- Projects on H₂ synthesis from CH₄ and carbon black formation

Team Development Roadmap

Function	Phase				
	Demo Plant Engineering	Demo Plant Construction	Demo Plant Operation	Module Commercialization	Commercialization at Scale
CEO	AG	AG	AG	AG	AG / New CEO?
Finance/HR/IT	Admin Contract Accounting	Admin Contract Accounting	Admin Contract Accounting HR	CFO/Controller Accountant x1 HR	CFO/Controller Accounting x3 HR
Operations	EB Project manager	EB Project manager Contract construction	EB Project manager x2 Field engineers x2	EB / VP – Operations? Project manager x5 Field engineers x10 Ops team x10	EB / VP – Operations? Project manager x10 Field engineers x20 Ops team x40
Engineering	MT Engineers x2 Contract engineering	MT Engineers x2 Contract engineering	MT / VP – Engineering? Engineers x2	MT / VP – Engineering? Engineers x10	MT / VP – Engineering? Engineers x20
Sales & Marketing	AG	AG	AG Sales x2	AG / VP – Sales? Sales x10	AG / VP – Sales? Sales x20

Our Vision

“Over \$190 billion of hydrogen is produced every year, emitting more than 750 million tonnes of CO₂. Aurora’s technology is in a **fundamentally low-cost position** relative to other methods of hydrogen production, while generating zero CO₂ emissions. We believe that **Aurora has the potential to dramatically reduce carbon emissions while becoming a multi-billion dollar company.**”