Element 1
Powering Innovation

Advanced Development of Hydrogen Generator Technology for Applications in Commercial Solutions

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Element 1 Corp (e1)

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Scalable.
Reliable.
Affordable.

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Element 1 Corp

Scalable, Reliable, and Affordable H_2 Generation

- e1 is a leading developer of small-scale advanced H_2 generation systems supporting the fuel cell industry
- e1 collaborates with its strategic licensing partners to produce state-of-the-art H_2 generation systems used in clean energy solutions
- e1 seeks to partner with global companies that have the capital and market channel to broadly commercialize e1 technology

Founded in 2010 in Bend, Oregon

e1 China:

- Source new licensing and partnerships in China
- Oversight and administration of China-based operations
- Maximize value of JV and execute future liquidity event

Element 1 Corp Introduction Video (Hyperlink)

e1 Business Model

Customer Profile

- Develop H_2 technology
- Assemble and provide sample (demonstration) products for evaluation by partner companies
- **Licensing business model** to get products to market worldwide (**not** a commercial manufacturer of H_2 generators)
- License partners manufacture e1 H_2 generator products and provide the sales channel to defined markets
- **e1's customer profile:**
  - Fuel cell technology developers
  - Fuel cell system integrators
  - Market-leading OEM's who want to acquire fuel-cell related technology to maintain or grow market share

e1 H_2 Generators have been integrated with PEMFC's by:

BALLARD®

HYDROGENICS
SHIFT POWER | ENERGIZE YOUR WORLD

Nedstack
PEM FUEL CELLS

Horizon
Fuel Cell Technologies

altergy®
Leading the Fuel Cell Revolution

Top+ energy
Toplus Energy Corporation

e1 Products & Markets

Scalable, High-Value Solutions at an Affordable Cost

Critical Infrastructure

Reliable and cost-effective H_2 generators supporting critical infrastructure

S-Series

FCEV H_2 Refueling Stations

Scalable H_2 generators supporting fleet FCEV refueling stations

L-Series

Mobile H_2 Generation

Mobile (on-board) H_2 generators for bus, truck, tram and marine fuel cell solutions

M-Series

Material Handling

On-site H_2 generators for your material handling fleets

L-Series

Methanol

Superior, H_2-Dense Fuel

- e1 H_2 Generators use liquid Methanol & Water to produce H_2 on-site, and on-demand for PEM fuel cell solutions
- Considering e1's H_2 generation technology is an evaluation of whether compressed H_2, or a liquid H_2 carrier (Methanol & Water) is the best source of H_2 fuel for a specific fuel cell application

Methanol IS the Superior Fuel

- Methanol has the **LOWEST** carbon content and **HIGHEST** H_2 content of any liquid fuel
- Methanol has **FOUR-TIMES** the energy density of compressed 350 bar H_2
- As stored **energy demand increases**, **METHANOL** becomes the preferred source of H_2
- Clean exhaust emissions: **NO NO_x** | **NO SO_x** | **NO Particulate Matter**

S-Series H_2 Generator

On-Demand H_2 Generator for *Critical Power Solutions*

Overview

- **Model:** S-Series was designed to displace expensive cylinders of compressed H_2 for critical power applications where long runtimes are required
- **Target uses:** 4G/5G telecom, railroad infrastructure, broadband cable operators
- **Mature Technology:** Proven design, developed over 20 years
- **Feedstock:** Methanol and DI water
- **H_2 Purity:** Fuel Cell Grade, >99.97% with <1 ppm CO and <1 ppm CO_2
- **H_2 Production:** Can scale to produce from 12 to 100 sL/m and support 1 kW to 7.5 kW PEM fuel cell
- **Operation:** Designed for cyclic and variable operation

Reliable, Low Cost H_2 Generation for Small Scale Power Generation

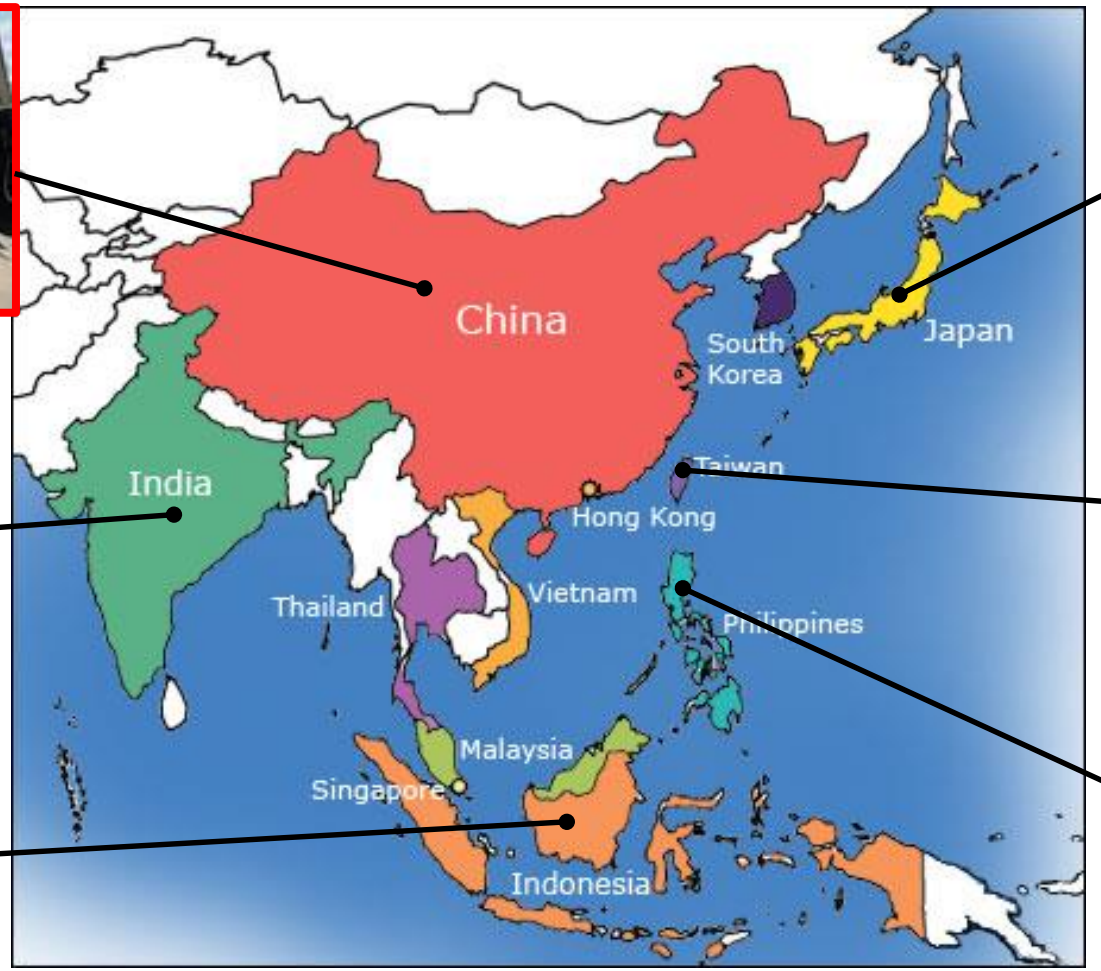
Deployments Worldwide

Asia Focus

China

India

Indonesia



Japan

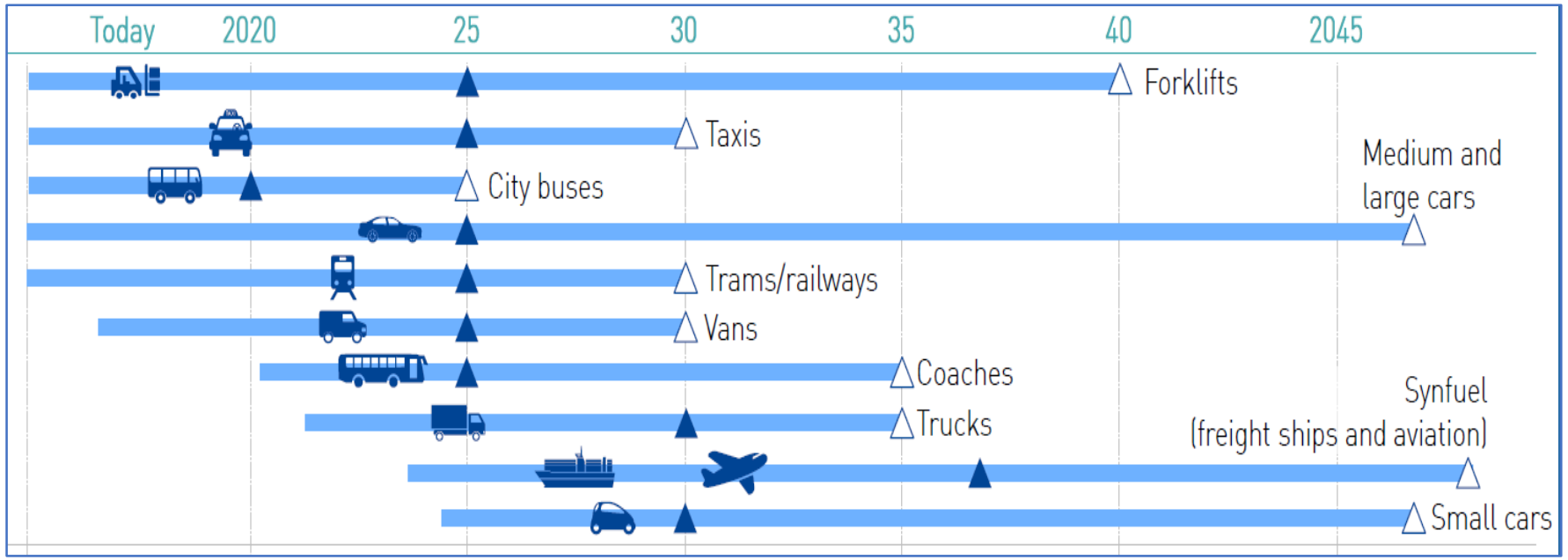
Taiwan

Philippines

Transportation Market

Source: McKinsey & company, "Hydrogen Scaling Up" for Hydrogen Council, November 2017

- Commercialization of electric vehicles (EVs) is growing strongly in major markets.
- The development of BEVs and FCEVs is likely to be synergetic
  - Both technologies rely on electric powertrains and benefit from technological improvements in these components
- **H_2-powered vehicles** are commercially available now or within the next five years in medium-sized/large cars, buses, trucks, vans, trains, and forklifts



H_2:
- **KEY** technology in a decarbonized transport system

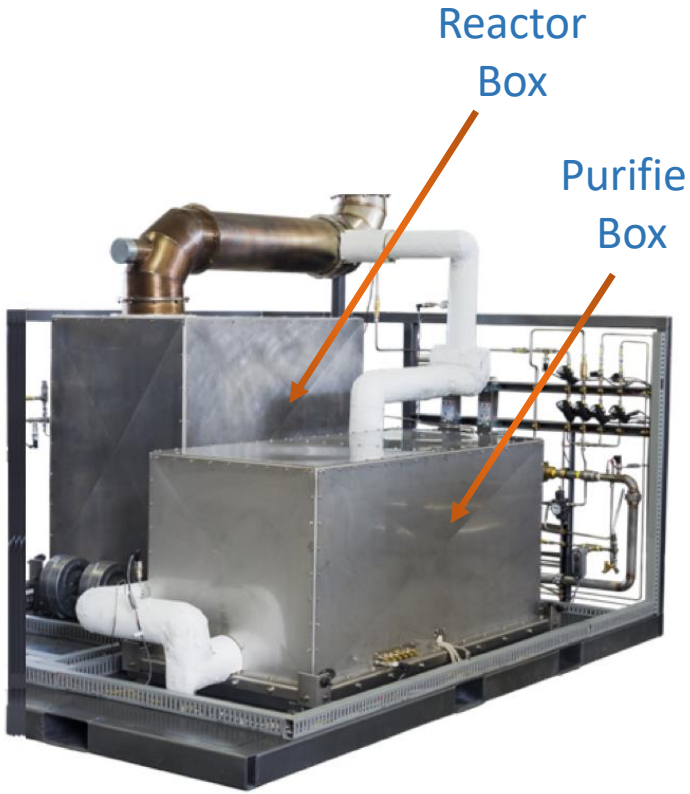
Methanol:
- Higher energy density per volume
- Can travel even longer distances compared to stored H_2

M-Series H_2 Generator

On-Board H_2 Generation for ***HD Vehicles***

Designed to displace compressed or liquid H_2 to support mobile fuel cell propulsion solutions

- **Mature Technology:** Developed over 20 years, multiple product lines
- **H_2 Production:** Can scale to support 30 kW to 300 kW
- **H_2 Purity:** >99.97% with <1 ppm CO and <1 ppm CO_2
- **Vibration Resistant:** Designed for transportation applications
- **Operation:** Designed for cyclic and variable operation
- **Feedstock:** Methanol and DI water
  - 6.3 kg methanol/ mix water yields 1.0 kg pure H_2
- **Power Required:** < 6 kW per 500 kg/d of H_2 produced
- **Lifetime:** Designed for greater than 10,000 hour lifetime (H_2 production)
- **Manufacturing:** Under e1 manufacturing license



M-Series H_2 Generator

M-Series

Specifications by Model

M-Series Specifications			
FUEL REQUIREMENTS			
METHANOL/WATER BLEND RATIO	Premixed | Methanol 62-63 wt% with balance DI water		
METHANOL SPECS	Methanol must meet IMPCA purity standard		
DE-IONIZED WATER SPECIFICATIONS	DI water must meet ASTM Class III purity standard		
PRODUCT HYDROGEN (MODEL)	**M60**	**M150**	**M300**
OUTPUT	95 kg H_2/day	235 kg H_2/day	475 kg H_2/day
SUPPORT PEMFC SIZE (12 sLm per kW)	60 kW	150 kW	300 kW
PURITY (Fuel Cell Grade)	>99.97% with <1 ppm CO, < 1 ppm CO_2		
TEMPERATURE	Ambient (fuel storage temperature)		
PRESSURE SUPPLIED TO PEMFC	10-30 PSIG		
COMMUNICATION			
CONTROLS & REMOTE MONITORING	Woodward Flex 500 control package		
INTERFACE	Graphical user interface		
OPERATING MODES	Automated		
ELECTRICAL POWER REQUIREMENTS			
ELECTRICAL POWER SUPPLY	2.0 kW	3.5 kW	6.0 kW
POWER DRAW IN RUN MODE	1.5 kW	3.0 kW	4.5 kW
EFFICIENCY			
METHANOL/WATER CONSUMPTION	0.8 L/min	2.0 L/min	4 L/min
EFFICIENCY AT STEADY STATE OPTIMAL	>70% based on insulation package and exhaust heat recovery		
DIMENSIONS & WEIGHT			
LENGTH	2.4 m	3.8 m	5.0 m
WIDTH	3.0 m	3.0 m	3.0 m
HEIGHT	1.0 m	1.0 m	1.0 m
INSTALLATION APPROXIMATE AREA	7.2 m^2	11.4 m^2	15 m^2
WEIGHT	600 kg	1,500 kg	3,000 kg

M-Series H_2 Generator

Key Advantages

Very Low TCO

Scalable

Low Noise, Vibration, & Emissions

Small Footprint / Flexible Configuration

Minimal Electrical Power Requirements

Easy to Operate & Maintain

Accelerates the Adoption of HD Fuel Cell Vehicles

L-Series H_2 Generator

On-Demand H_2 Generator for *H2 Refueling Stations*

Designed to displace compressed or liquid H_2 to support H_2 fueling and stationary power

- **H_2 Production:** Can scale to produce 50 kg/d to 500 kg/d
- **Woodward Controls:** World-class controls for reliable operation
- **Power Required:** ≤ 6 kW per 500 kg/d of H_2 produced
- **Feedstock:** Methanol and DI water
  - 6.3 kg methanol/water mix water yields 1.0 kg pure H2
- Displaces expensive H_2 produced offsite
- Competing electrolyzer solutions are expensive and have large electricity requirements that may not be available
- L-Series H_2 generator targets **HRS** and large stationary fuel cell power solutions

The L-Series H_2 Generator Provides the Lowest Total Cost of H_2 for Fuel Cell Solutions

L-Series

Specifications by Model

L-Series Specifications			
FUEL REQUIREMENTS			
METHANOL/WATER BLEND RATIO	Premixed | Methanol 62-63 wt% with balance DI water		
METHANOL SPECS	Methanol must meet IMPCA purity standard		
DE-IONIZED WATER SPECIFICATIONS	DI water must > 14MΩ-cm		
PRODUCT HYDROGEN (MODEL)	**L100**	**L250**	**L500**
OUTPUT	100 kg H_2/day	250 kg H_2/day	500 kg H_2/day
PURITY (Fuel Cell Grade)	>99.97% with <1 ppm CO, < 1 ppm CO_2		
TEMPERATURE	Ambient (fuel storage temperature)		
PRESSURE SUPPLIED TO PEMFC	10-30 PSIG		
COMMUNICATION			
CONTROLS & REMOTE MONITORING	Woodward Flex 500 control package		
INTERFACE	Graphical user interface		
OPERATING MODES	Automated		
ELECTRICAL POWER REQUIREMENTS			
MAX ELECTRICAL POWER SUPPLY	2.0 kW	3.5 kW	6.0 kW
MAX POWER DRAW IN RUN MODE	1.5 kW	3.0 kW	4.5 kW
EFFICIENCY			
METHANOL/WATER CONSUMPTION	0.56 L/min	1.4 L/min	2.8 L/min
EFFICIENCY AT STEADY STATE OPTIMAL	>70% based on insulation package and exhaust heat recovery		
DIMENSIONS & WEIGHT			
LENGTH	2.4 m	3.8 m	5.0 m
WIDTH	3.0 m	3.0 m	3.0 m
HEIGHT	1.0 m	1.0 m	1.0 m
INSTALLATION APPROXIMATE AREA	7.2 m^2	11.4 m^2	15 m^2
WEIGHT	600 kg	1,500 kg	3,000 kg

加氢站方框图
H_2 Fueling Station—Block Diagram

制氢设备
（L系列或电解制氢）
H_2 Generator
(Electrolyzer or L-Series)

压缩
Compression

高压储存
High-Pressure Storage

加氢机
Dispensing

经济效益分析的结论

- 资本成本是水电解的25%
- 运行成本是水电解的50%

Conclusion of economic analysis

- CAPEX is only 25% of electrolyzer
- OPEX is only 50% of electrolyzer

L-Series

HRS - H_2 Refueling Station

→ **The L-100 H_2 generator is designed for applications such as:**

- H_2 refueling stations for heavy duty motive vehicles
- Maritime
- The demo system has been operating in Guangdong province successfully
- On-going testing is being carried out on routine basis

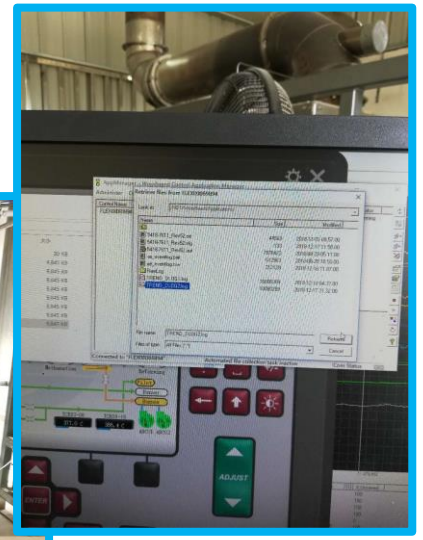
L-Series H_2 Generator

100 Hours of Operations

Experiment:

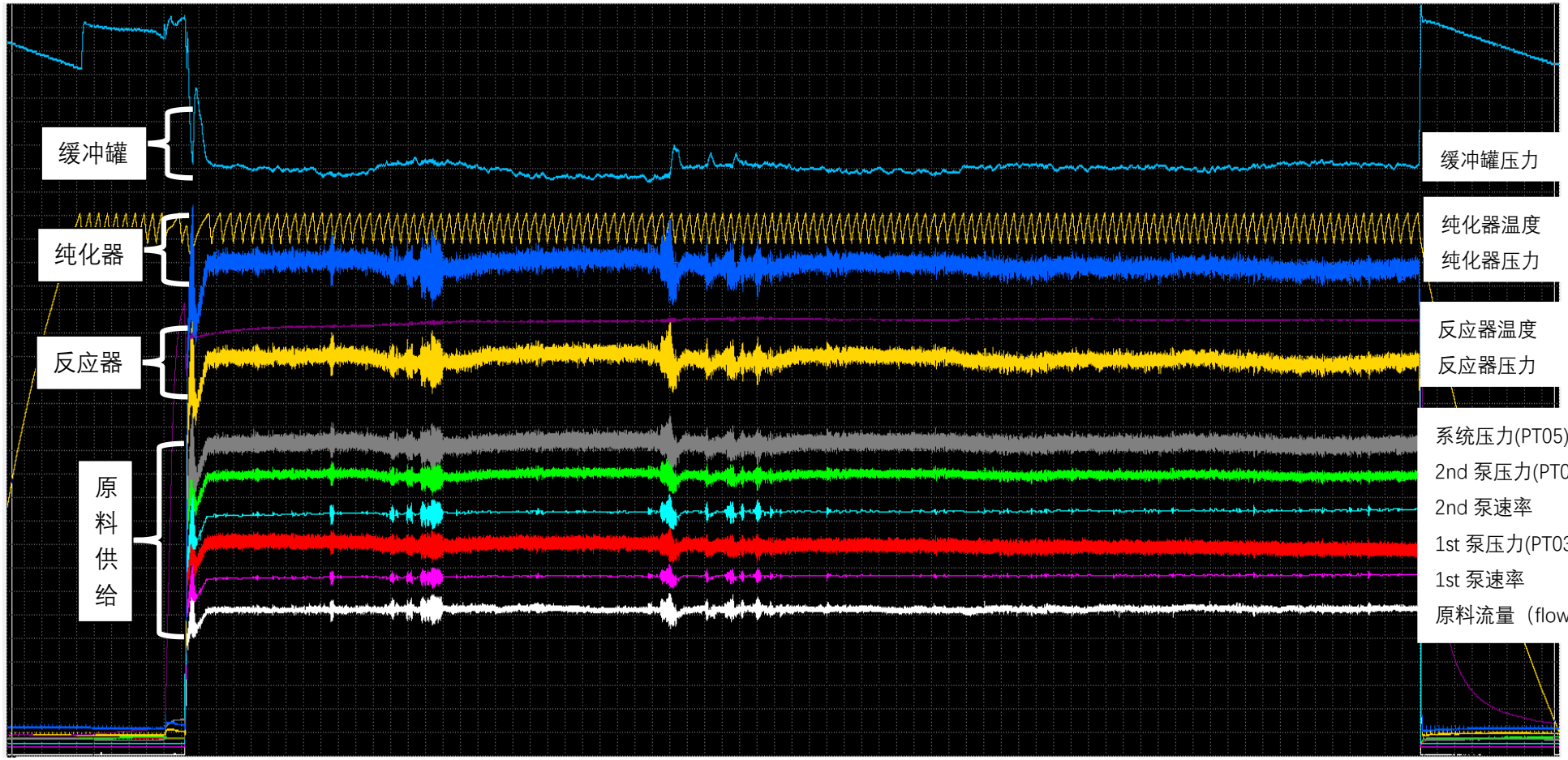
- During: 18:30 Dec 16 to 22:36 Dec 20, 2018. TOTAL: 100 hours
- H_2 production: 760 SLPM, about 100 kg/day (steady)
- Accumulated hours: 200 – 300 hours

Feedstock Preparation



L-Series H_2 Generator

100 Hours of Operations



L-Series Compared to Electrolyzer

e1 L-Series

- **Pure H_2 produced from methanol & water**
  - 6.3 kg methanol yields 1.0 kg pure H_2
  - At US$410/ton methanol → 6.3 kg methanol costs US$2.58
  - Minimal maintenance cost
- **CapEx is less than 35% to 50% that of electrolyzers**
  - In commercialization, CapEx is estimated to be:
    - $100,000 to $150,000 for 100 kg H_2/day
    - $250,000 to $300,000 for 300 kg H_2/day
- **If renewable methanol is used, zero net CO_2 emissions**

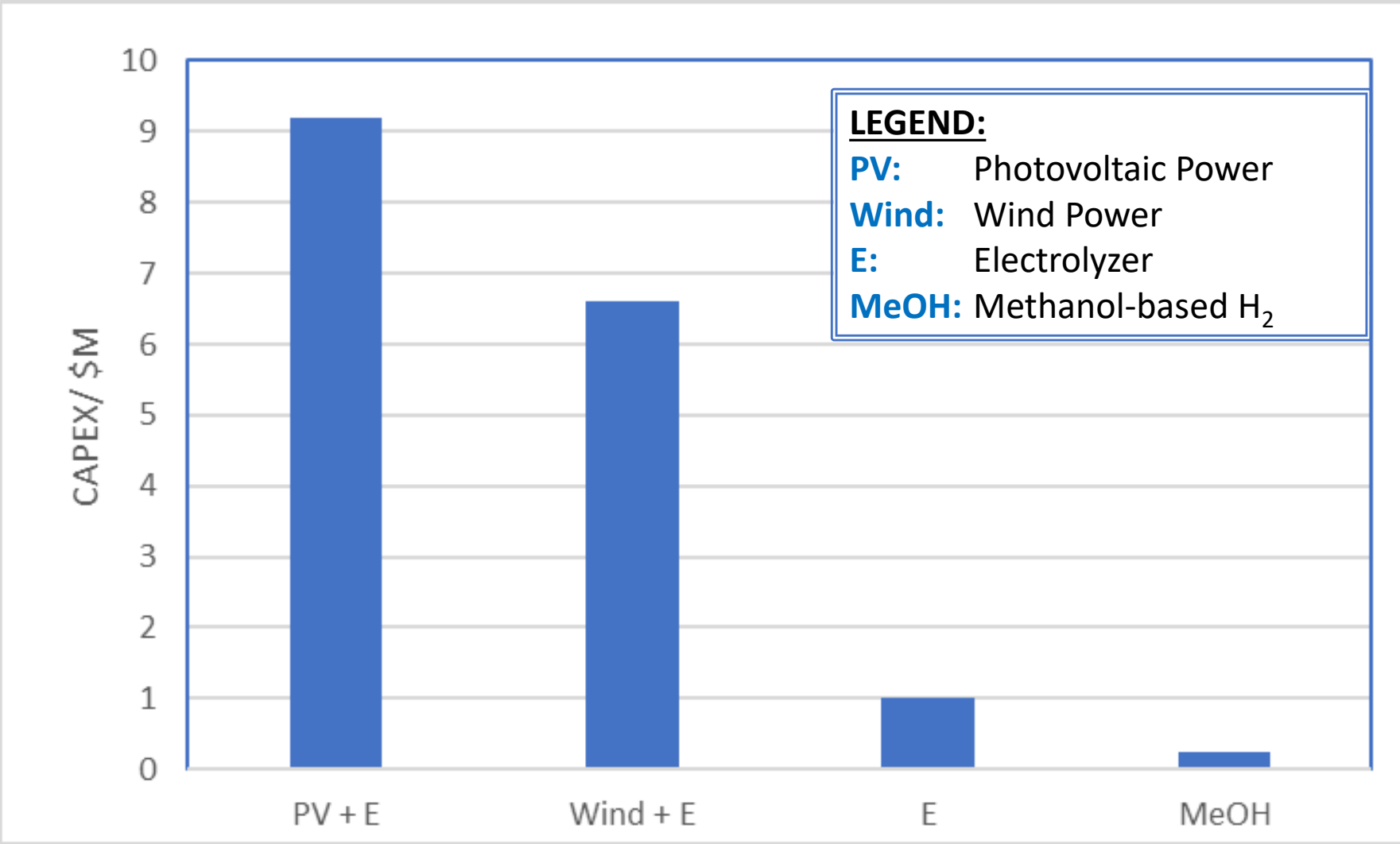
Electrolyzer

- **Pure H_2 produced from electricity & water**
  - 55 kWhr electricity yields 1.0 kg pure H_2
  - At US$0.10/kWhr → 55 kWhr costs US$5.50
  - At US$0.05/kWhr → 55 kWhr costs US$2.75
  - Significant maintenance cost to deliver high-purity water to the electrolyzer
- **High CapEx**
  - Approx. $560,000 to $750,000 for 100 kg H_2/day
  - Approx. $950,000 to $1,400,000 for 300 kg H_2/day
- **If renewable electricity is used, zero net CO_2 emissions**

H_2 Generation
Comparison of PV, Wind and Electrolyzer with Methanol Method

Assumptions:

- 300 kg H2/day
- Electrolyzer when operating alone requires power from main grid.
- About 70% of grid power comes from coal fire power plant in China



e1 H_2 Generator Provides *Significant Cost Reduction*

40%+ Reduction on the Cost of H_2

$/kg

Cost of H_2 to Site

Compression, storage, and dispensing are common for all solutions

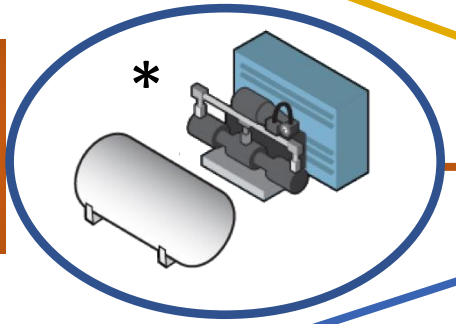
$8 to $12 /kg

H_2 Gas

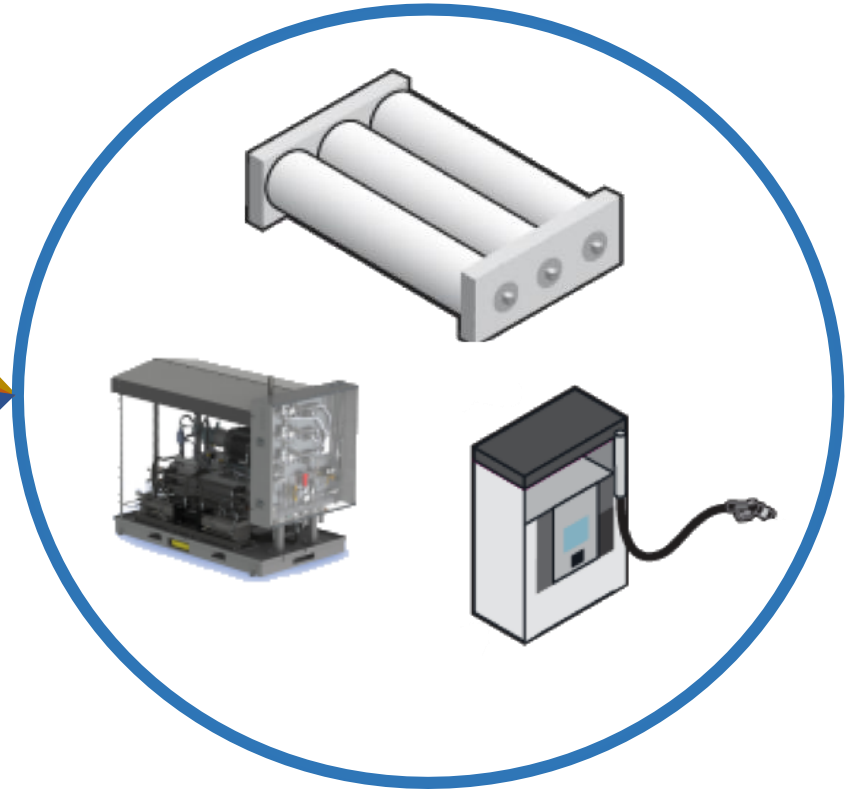
$5 to $8 /kg

H_2 Liquefied

*



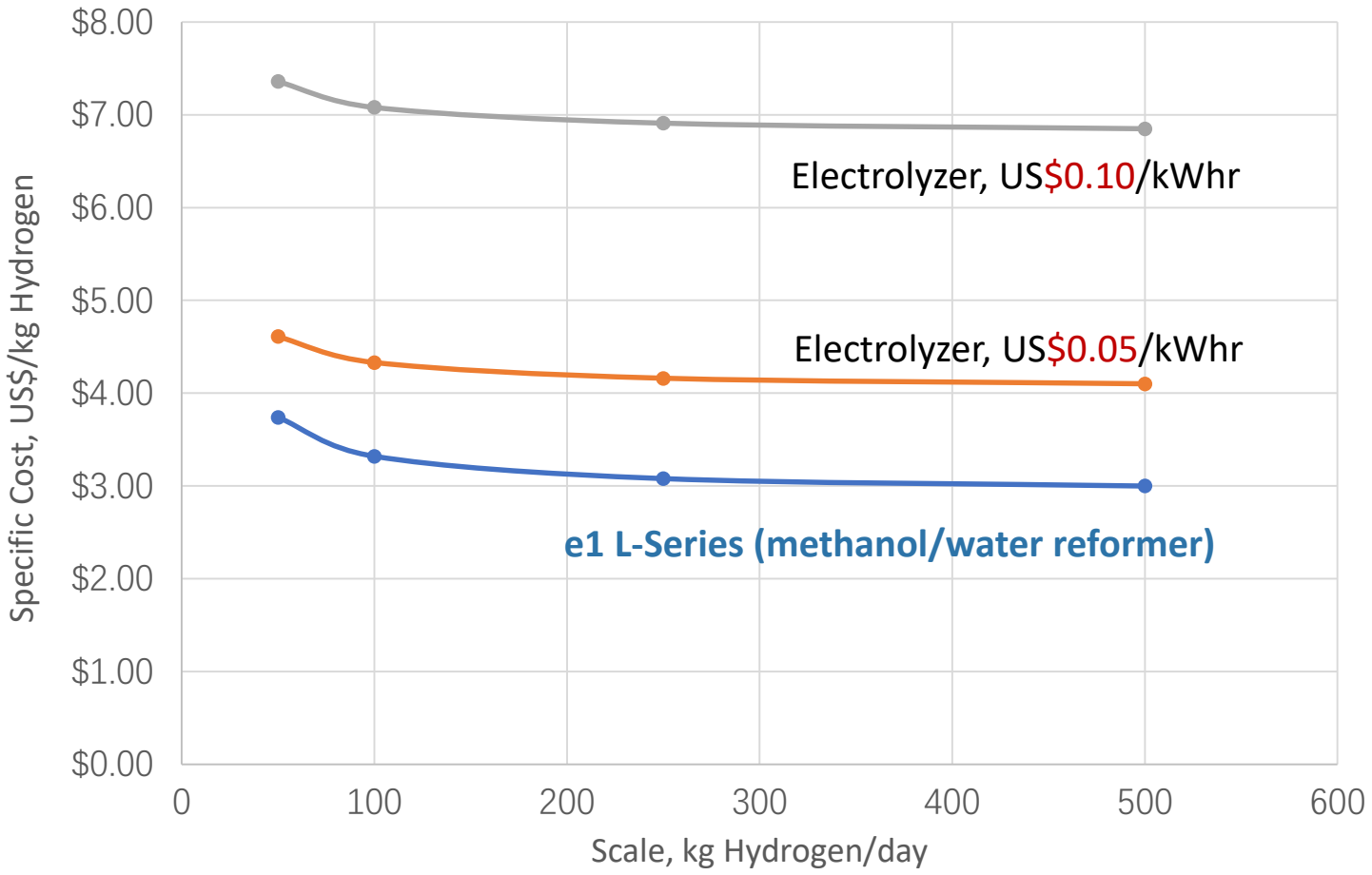
$3 to $4 /kg



* Liquefied H_2 has additional CapEx

Cost of H_2

L-Series compared to Water Electrolyzer



Cost of making H_2 onsite

(excludes cost of compression, high-pressure storage, and dispensing)

→ **L-Series H_2 Generator costs include:**

- Amortization of CapEx for the L-Series H_2 generator (5-year depreciation)
- Cost of methanol feedstock (US$410/ton)
- Maintenance

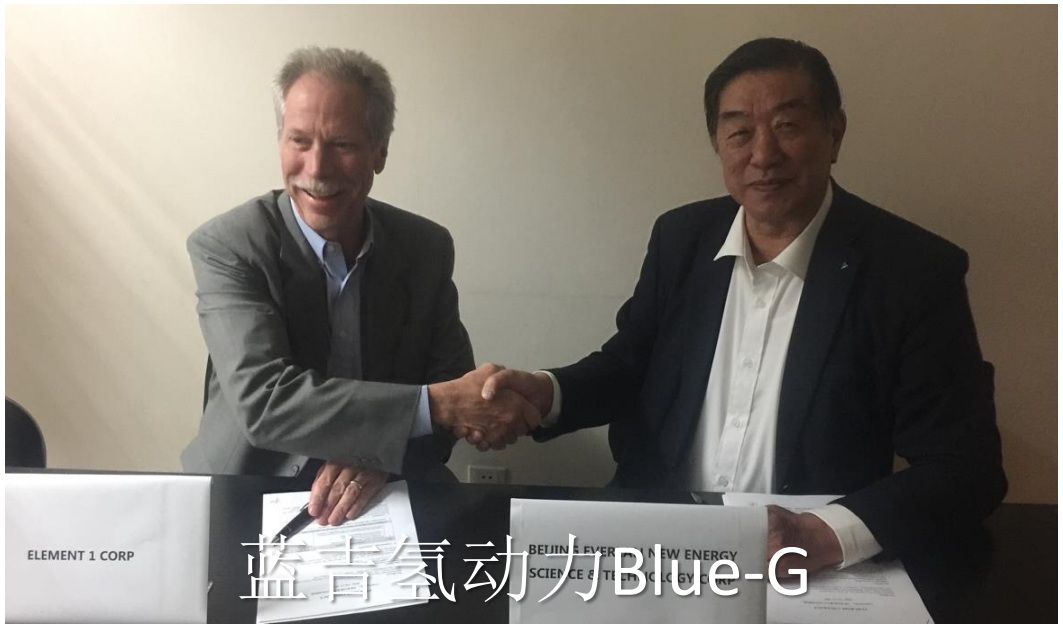
→ **Water Electrolyzer costs include:**

- Amortization of CapEx for the water electrolyzer (5-year depreciation)
- Cost of electricity (see graph)
- *No cost included* for maintenance and for water purification

合作伙伴
Current Collaborations

现有客户还包括:

- 香港水化集团
- 国鸿氢能
- 蓝吉氢动力
- 台湾省著名的燃料电池企业
- 广东力行科创氢能

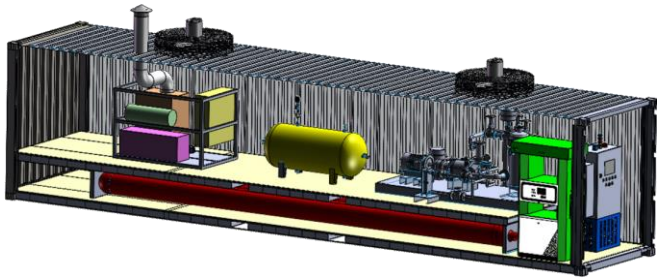


Current collaborations:

- Aqueous Hydrogen Energy
- Nation Synergy
- Blue-G
- Prominent Fuel Cell Company in Taiwan Province
- Adamant Innovation Hydrogen Energy

Take Home Message

1. Methanol-based technology is the most economical solution for hydrogen generation now.
2. This technology is commercially available now



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Thank You

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Scalable.
Reliable.
Affordable.

e1 H_2 Generation Products

Commercialization Matrix

		TRANSPORTATION						POWER GENERATION				INDUSTRIAL	
		HRS - H_2 Refueling Station		Mobility				O&G	Stationary Power		Mobile Power	H_2 Gas	Waste H_2
		On-Road	Lift Trucks	Comm. Vehicle	Off Highway	Marine	Rail	Various	PEM Fuel Cell			Production	Clean Up
e1 Products	TRL	50 - 500 kg/d		30 kW - MW				< 300 Mscfd	1 - 10 kW	30 - 300 kW	30 - 50 kW	50 - 500 kg/d	< 500 kg/d
H_2 Purifier	9	●	●	●	●	●	●		●	●	●	●	●
S-Series	9								●		●		
L-Series	7	●	●							●		●	
M-Series	6			●	●	●	●						
GTW	9							●					

- e1's develops H_2 generators designed to support a range of fuel cell market applications
- Available in three models that span a range of product H_2 flow rates from 15 standard liters per minute (1.9 kilograms per day) to 100 kilograms per day at a purity >99.95% H_2 (Fuel Cell Grade)
- e1 H_2 generators are modular and highly scalable out to 500 kilograms per day while maintaining their breakthrough economics
- **Common attributes of e1 H_2 generators:** Very Low CapEx, Very Low OpEx, Lowest TCO H_2 kg/d, Compact Design, Low Noise, and Low Maintenance

M-Series H_2 Generator
Key Advantages (1 of 2)

1. **Solves "The Hydrogen Challenge":** Limitations related to high-pressure gas or liquid H_2 storage, availability of H_2 and the total cost of H_2
2. **Flexible Application:** APU, propulsion, cold-Ironing
3. **Very Low TCO:** Very low CapEx and OpEx, produce H_2 for $3 to $5 per kg onboard the vessel
4. **Scalable H_2 Production:** Support 30 kW to 300 kW fuel cells per M-Series module
5. **Support Significant Power Generation:** Multiple M-Series can be operated in parallel to support MW scale power production
6. **Distributed Power Generation:** Multiple M-Series units can be integrated with fuel cells supporting modular power production at various locations on the vessel
7. **Reforms H_2-Dense Methanol / Water:** Extends range of fuel cell vessel, and reduces feedstock fuel storage requirements
8. **Simple / Familiar Feedstock Storage:** No stored high-pressure H_2 required, improved safety

Accelerates the Adoption of HD Fuel Cell Vehicles

M-Series H_2 Generator
Key Advantages (2 of 2)

1. **Small Footprint / Flexible Configuration:** The reactor box and purifier box can be resized or separated to meet vessel design constraints
2. **Minimal Electrical Power Requirements:** No special electrical infrastructure required
3. **Easy to Operate:** Requires little oversight to operate and maintain
4. **Easy to Maintain:** Few moving parts and long lifetime of major components > 10,000 operational hours reduces maintenance requirements
5. **Low Noise and Vibration Signature:** Improve comfort for the crew and passengers
6. **Reduces Emissions:** Easy to comply with criteria pollutant emissions of SO_x, NO_x, PM (particulate matter or soot), and CO_2
7. **No need for Exhaust Scrubbers:** Fuel reforming produces no soot (PM) reducing system cost, safe for arctic environments
8. **Excellent for use in Cold Environments:** Methanol has very low freezing temperature compared to petroleum fuels

Accelerates the Adoption of HD Fuel Cell Vehicles