Production Proof of Activated Al flakes for Hydrogen Generation On-demand

FROM:

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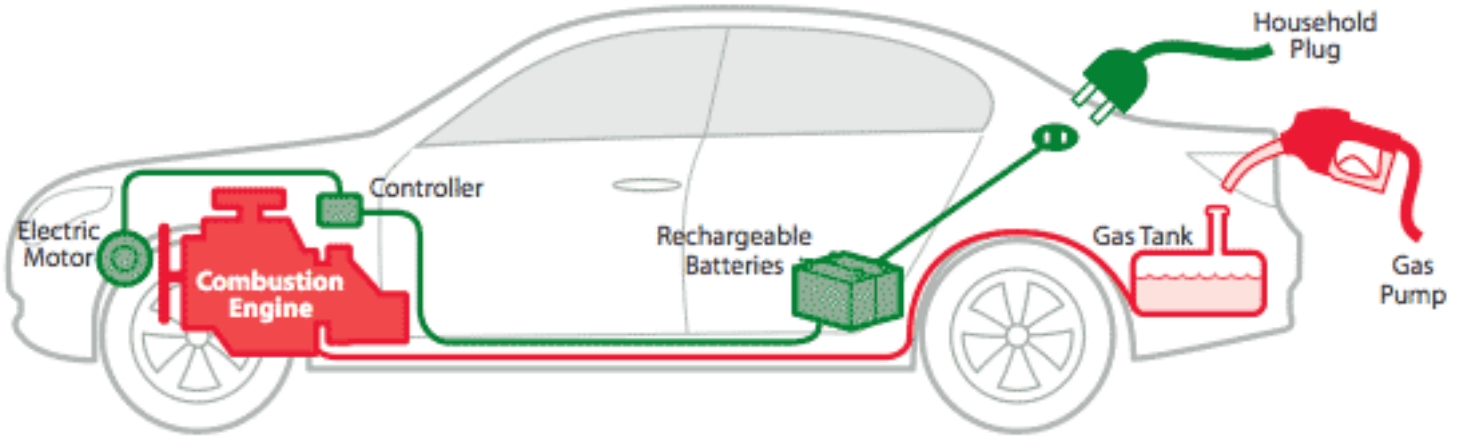
Electric vs. Gasoline

Electric	Gasoline
No Tailpipe Emissions	Greenhouse Gases/Pollution
Utility Company	OPEC
100+/- Mile Range	300+ Mile Range
Hours to Recharge	Minutes to Refuel
2 cents per mile	12 cents+ per mile

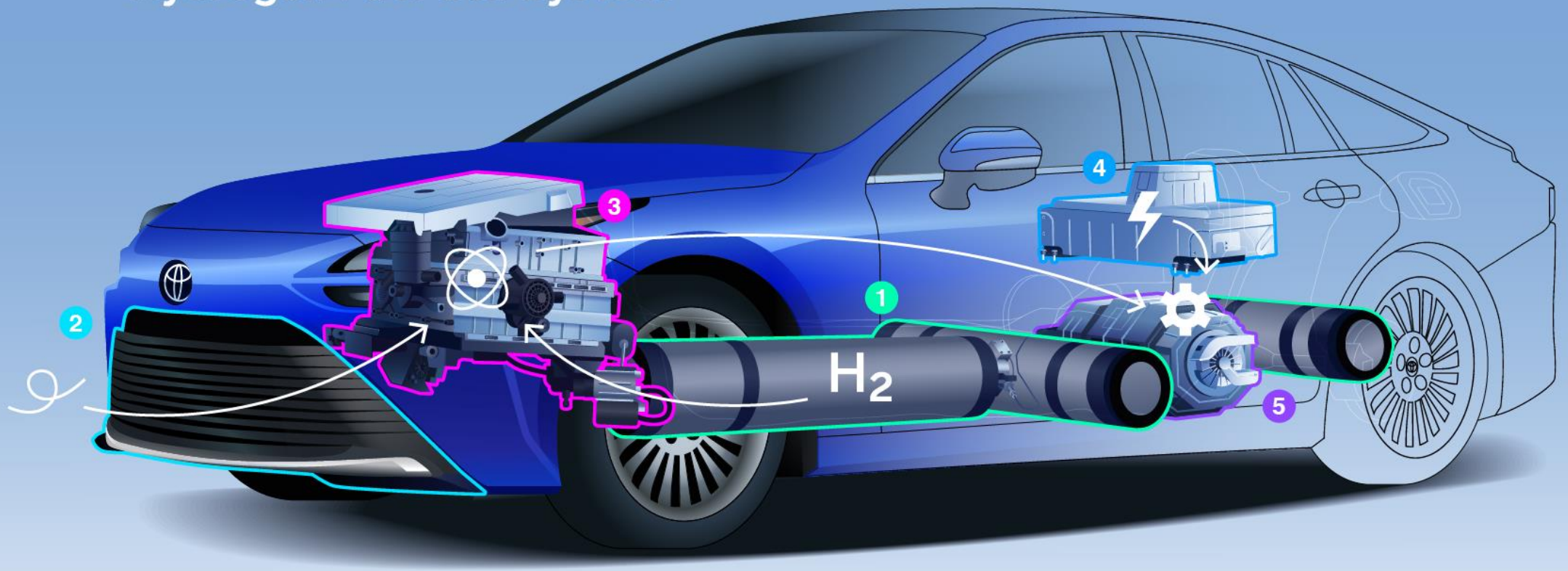


- Long Range (~400)
- Fast Charging/refuelling
- No Pollution
- Lightweight

The All-New

MIRAI

Hydrogen Fuel Cell System



1 Hydrogen Tanks
Distribute Hydrogen to the Anode of the Fuel Cell System. Once here, electrons are stripped from the Hydrogen by a platinum catalyst.

2 Air Intake
Supplies Oxygen (air) to the Cathode side of the Fuel Cell System, which later combines with the now positively charged Hydrogen to produce water as a byproduct.

3 Fuel Cell System
Provides the right environment for the Hydrogen to form with the Oxygen to create electricity and water. This then generates the electricity that flows to the Electric Motor.

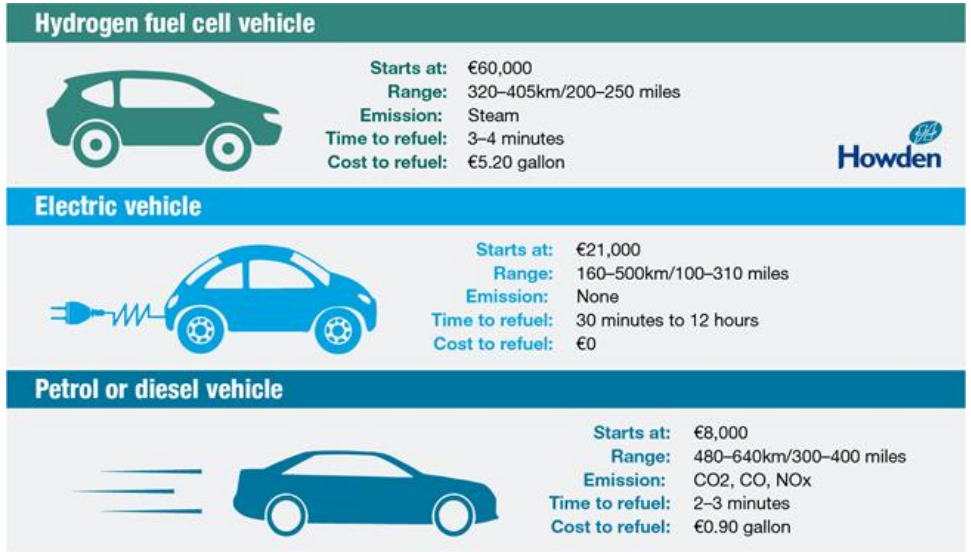
4 Battery
Supplies extra power and stores energy from regenerative braking.

5 Electric Motor
Powers and turns the wheel.

1. Why Hydrogen or why not?

A 2017 survey of 1,000 global auto executives concluded hydrogen fuel cell technology will ultimately outperform battery-powered electric vehicles.

Japan's first commercial hydrogen power plant to open near Mount Fuji. It is slated to begin operation by March 2022.



Fuel	Energy density (MJ/kg)
Hydrogen	119.7
Natural Gas	45.8
Petrol	44.8
Diesel	42.5

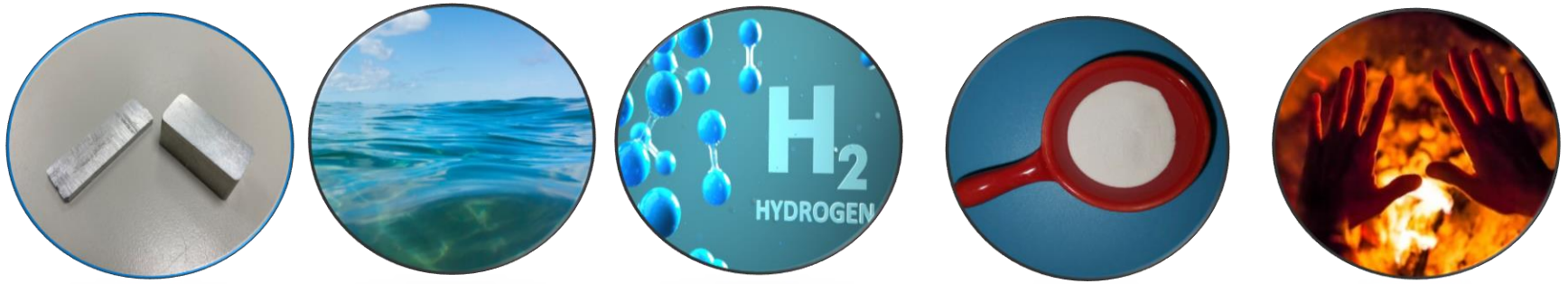
Source (Yip et al. 2019).

1. Our Product: Technological breakthrough

Our product represents **unique porous Al cassettes** that release hydrogen gas on-demand, upon reaction with sea water:

Chemical reaction we employ for the hydrogen production:

Al	+	3H2O	→	1.5H2	+	Al(OH)3	+	HEAT
1 kg		2 l		1,245 l		2.9 kg		4.3 kWh

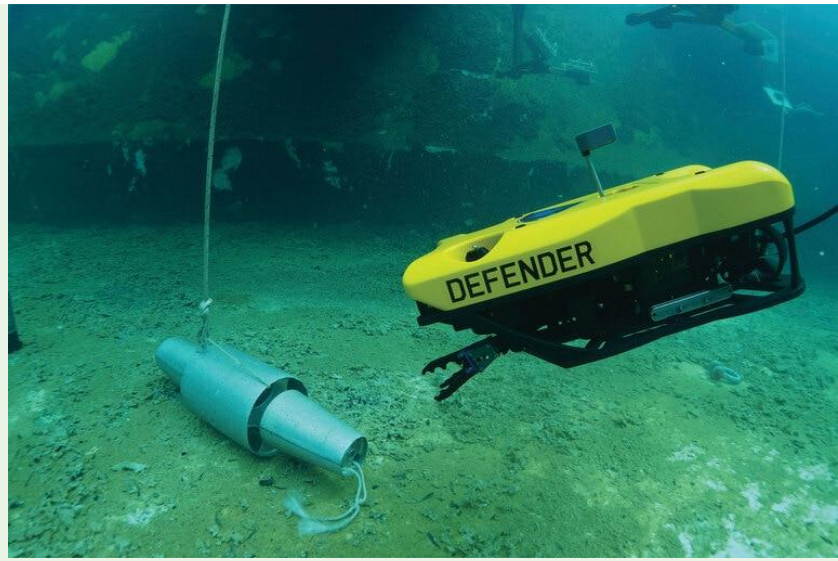


Cassettes	Sea Water	Hydrogen	Fire retardant clay	Heat
↑	↑	↓	↓	↓
Pigment Al particles	Sea	For Use	For Construction	For Heating

1 BACKGROUND. LIGHTWEIGHT FUEL CELL DEVICES

Hydrogen

H_2



GASEOUS

H_2 is stored in high-strength tanks at 350 bar

Relatively HEAVY

SOLID STATE

H_2 is stored in lighter tanks at 35 bar using METAL HYDRIDES

Relatively EXPENSIVE

WE NEED INEXPENSIVE !

1 PORTABLE H2 CONTAINERS

METAL HYDRIDE TECHNOLOGY

EXPENSIVE

HEAVY

REFUELING DIFFICULTIES

HIGH PRESSURE

HKUST TECHNOLOGY (US PATENT PENDING)

ACTIVE ALUMINUM PARTICLES

LYE ACTIVATOR

WATER

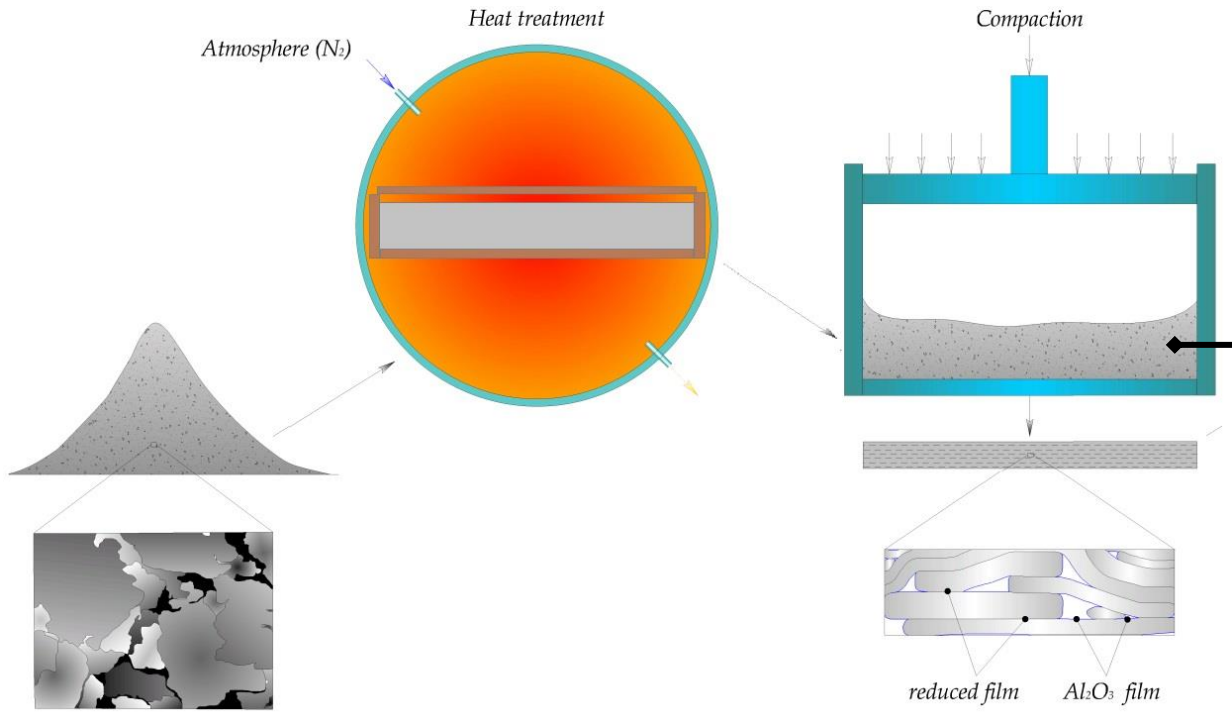
REDUCED

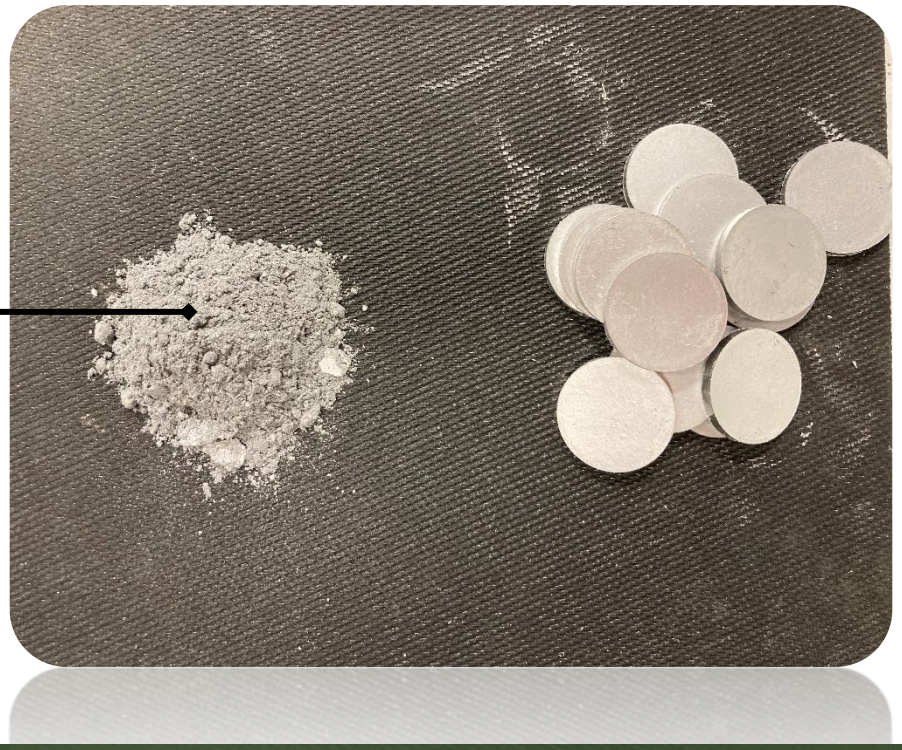
HEAT

CLAY

2. Our Product: How we made it

i. We undermined the protective skin on Al pigment particles with nanometric thickness by heat processing
ii. We compacted these particles into porous cassettes

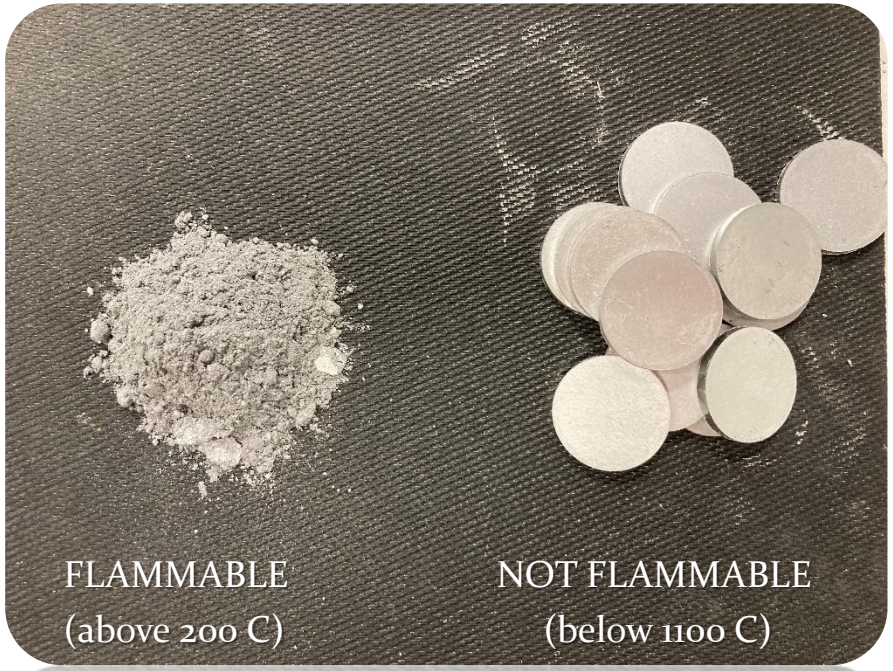




3. Our Product: Fire Safety

Usually, H2 generating powders are flammable and not safe for storage/transportation

Our product is not flammable and generates H2 only in water with a small amount of NaOH activator



CASSETTES (FIRE TESTING)

4. Results: Hydrogen generation

Compared to an Al foil, our cassettes generate H2 in water with a small fraction of NaOH

Al foil, thickness: 20 micron

Water: 4-20 wt% of NaOH
H2 Flow 10-40 ml/min

Prototypes testing:

Water: 0.5 wt% of NaOH
H2 Flow 100-130 ml/min

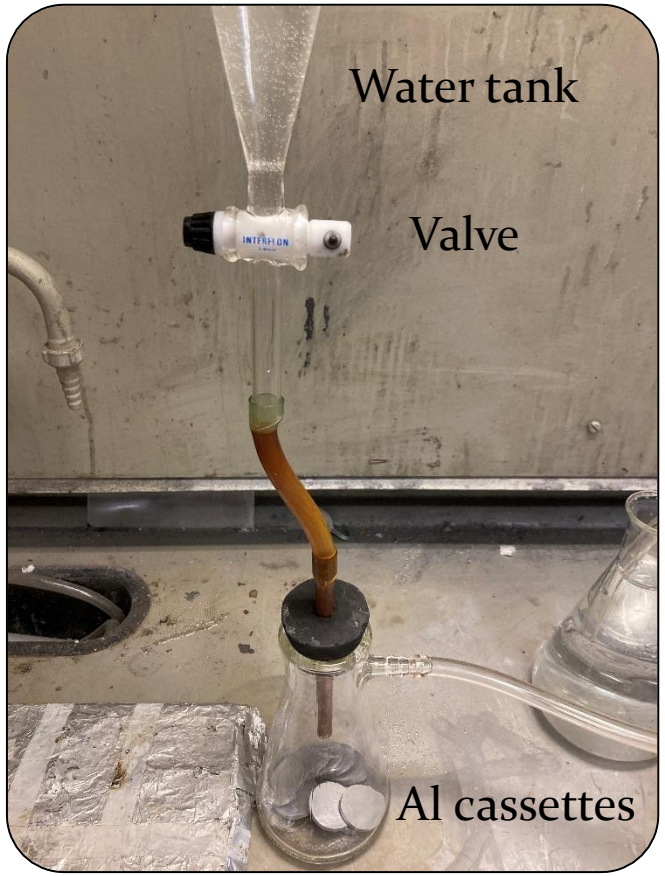
Other advantages:

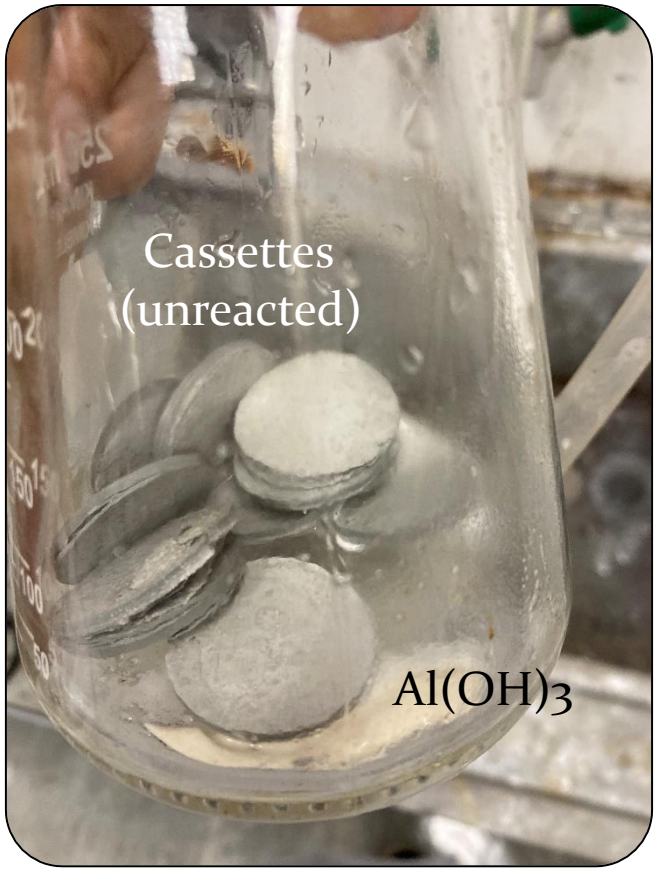
Bulk Density 1.6 g/cm^3
Fire safety: not flammable

Video: https://drive.google.com/file/d/1fS3LfCwPtarqE-lwdodpkeId4sEaTiaT/view?usp=sharing

5. Large scale testing

The Al cassettes (with activator) are put in a container to generate H2 just by connecting and opening a water valve





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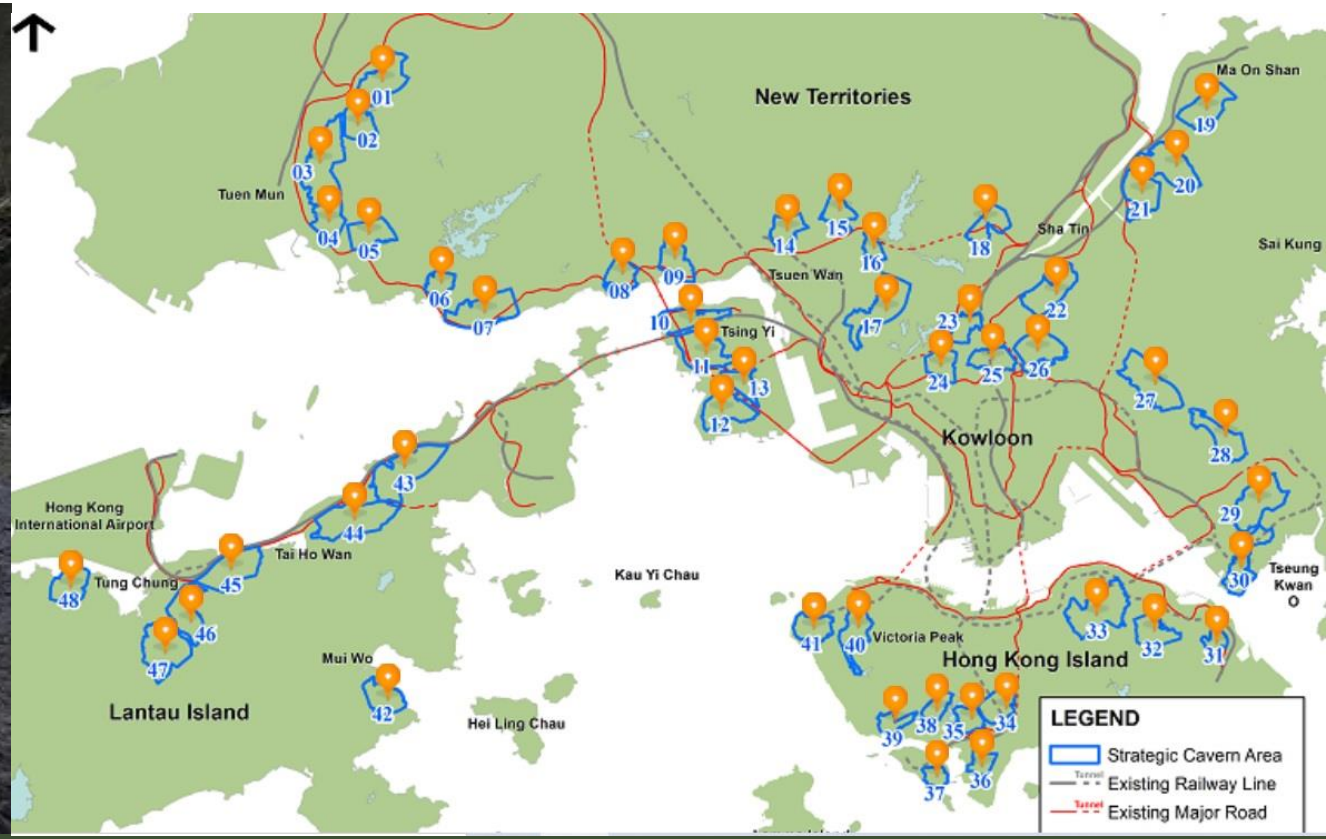
6. Typical Application: Cavern Development

To improve the work efficiency and air quality, the cavern developers are substituting diesel by new hydrogen equipment

UNDERGROUND WORKS

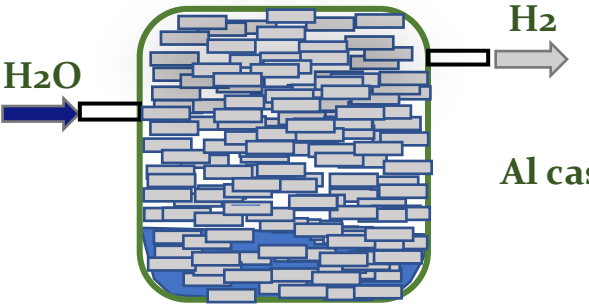


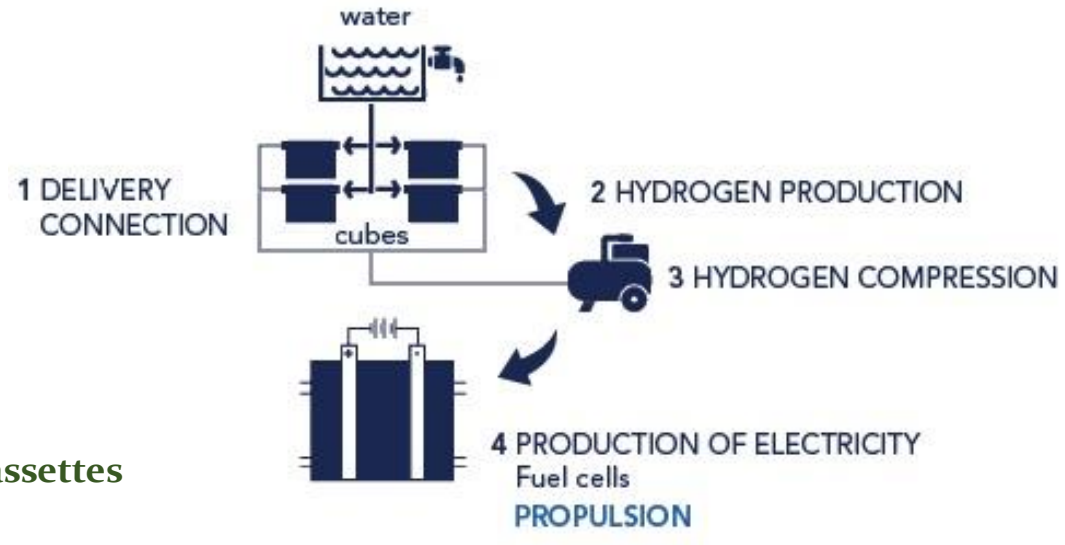
CAVERN MASTER PLAN

7. Cubes for the Al cassettes

The Al cassettes come in a plastic tare of high density polyethylene cubes (50×50×40 cm)

For instance, 4-5 cubes (130 kg each) power an electric excavator (122 kW) for one working day (8 hr)





8. Advantage of Cubes for delivery

Hydrogen gas is usually delivered and stored in high-pressure steel tanks

Proposal: Delivery of H2-generating Cubes to supply electric equipment

Advantages and disadvantages of H2 delivery in Steel tanks and Cubes

Refueling trucks with	Steel tanks	Cubes
Fire safety	acceptable	Non flammable
Specific weight	High	Low
Application	In Practice	New
Regulation	Developed	Required
Storage of all hydrogen	One place	generation on-demand

9. Economics: Case study

Electric excavator. Power: 122 kW

Operation	H2 required	Steel tanks (STD, 6.2 m3)			Cubes (0.5 × 0.5 × 0.4 m3)		
(hours)	(kg)	Number	Weight (ton)	Costs ($HK)	Number	Weight (ton)	Costs ($HK)
80 (10 days**)	75.1	136	8.82	62,451	5	0.68	54,055
1600 (200 days)	1,502	2,715	176.5	1,249,019	100	13.51	1,081,108

Reaction products are commodities

Extra for 160 hr	Amount	Est price ($HK)
HEAT	58,100 kWh	-70,893
Al(OH)3 fire retardant	39 ton	-216,973

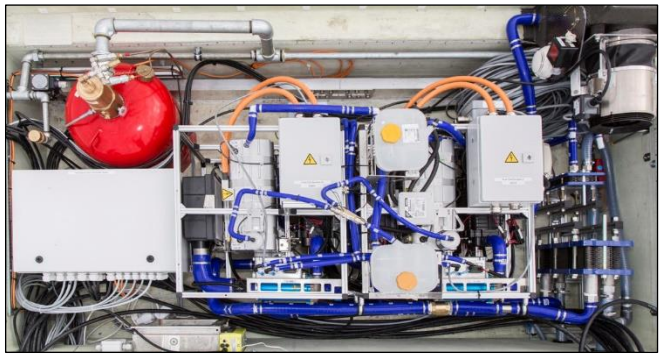
10 days normal operation = 8 hours of full power operation

9. Example: Travel Ship (100 dwt)

This is an on-going international project. Race for Water

Shipment Journey: Hong Kong to Taipei
Distance: 533 nm or **4.4 days** at 5 knots
Ship: **100 dwt** ship
Drive: 2 fuel cells × 30 kW

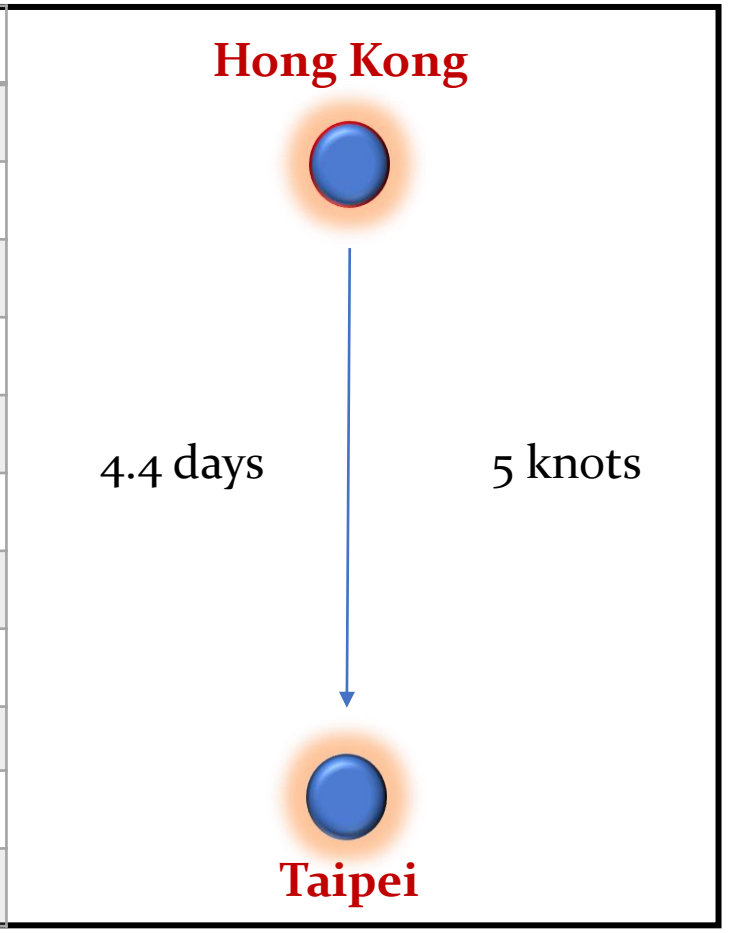
H2 Consumption : 487 **kg** per 4.4 days



9. Example: Cargo Ship (100 dwt)

Proposed project. The prices for materials are estimated for the manufacturing in Hong Kong

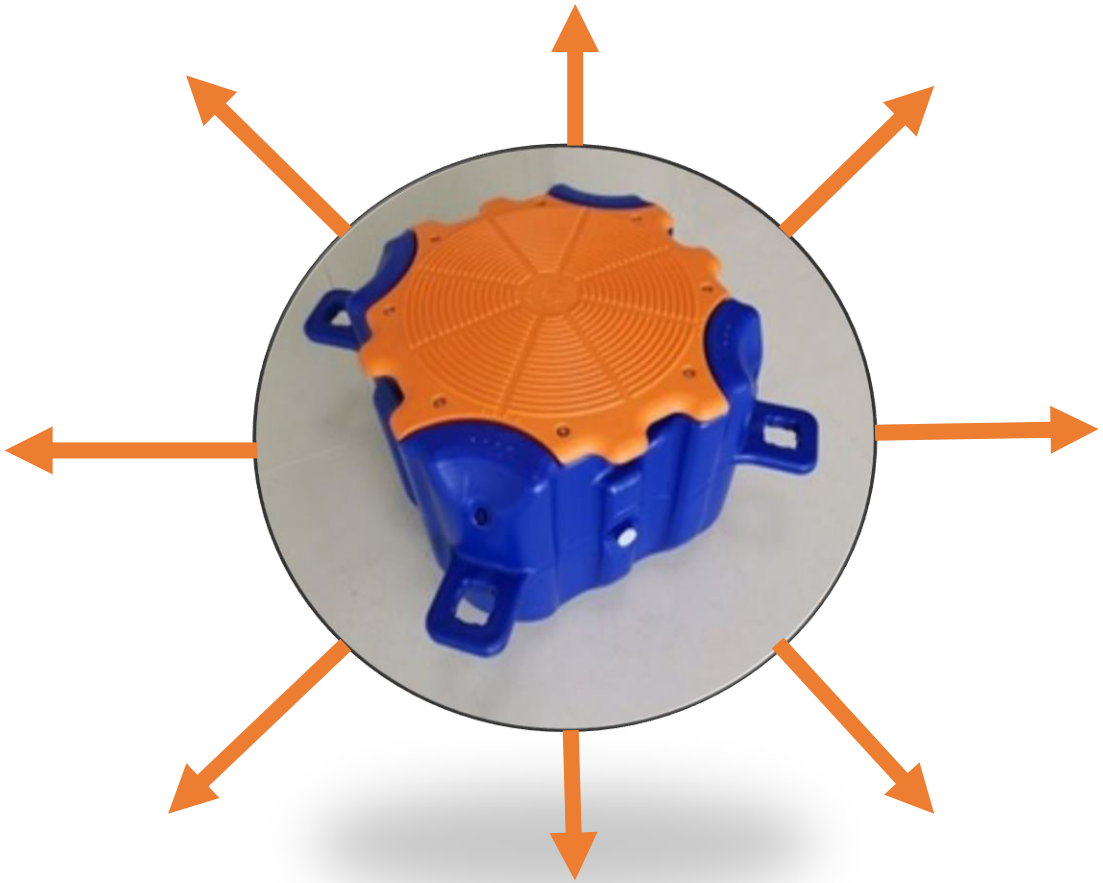
GUOFU (PRC)	Weight (ton)	Wt% of ship	Price (USD)	Ref
Hydrogen gas	0.49	0.49	43,865	90 USD/kg
H2 system. **19 items**	19	19	651,700	
TOTAL	19.49	19.49	695,565	
STEELHEADCOMP (US)				
Hydrogen gas	0.49	0.49	43,865	90 USD/kg
H2 system. **28 items**	28	28	2,058,000	
TOTAL	28.49	28.49	2,101, 865	
HKUST				
H2 cassettes	4.4	4.4	43,865	10 USD/kg
Chamber/additives	0.1	0.1	200	
TOTAL	4.5	4.5	44,065	



10. Economics: Reaction products are commodities

Fire retardant
Water purification
Medical antacid
Glass production
Dyeing

warming the underground space



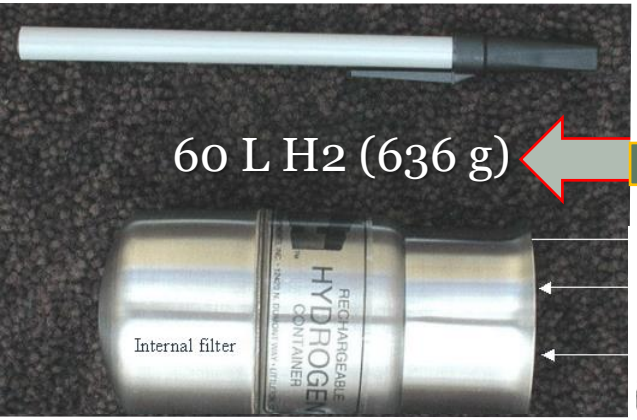
1 SOLID STATE H2 TECH

LaNi5

Al powder equivalent (theoret.)

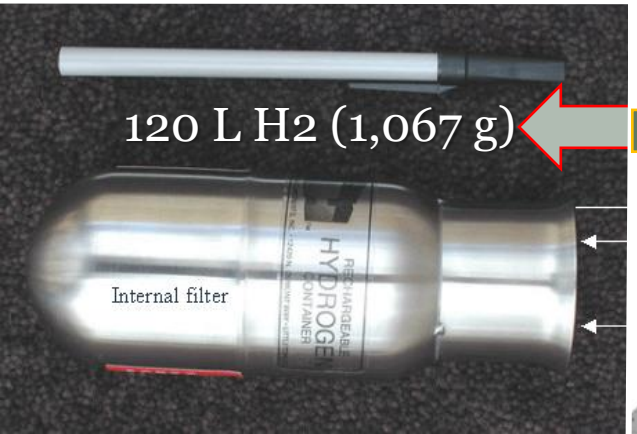
30 L H2 (438 g)

37 g



60 L H2 (636 g)

75 g



120 L H2 (1,067 g)

150 g

COMPARISON

Hydrogen carrier	LaNi5	Al particles
Refilling way	H2 pressure source	Replaceable container
Storage time	months	years
Refilling time	6 hours	6 sec
Cost of empty container	10,200 HK$	62 HK$
Cost of refilling (estim.)	5 HK$	10 HK$

1 CURRENT STAGE

POWDER CASSETTES

Handling:	Improved
Hydrogen Capacity:	Increased
Fire Safety:	Improved
Reaction Rate:	Decreased
Activation in Air	New

VIDEO

DESIGNING PORTABLE H_2 CONTAINER

(CURRENT STAGE)

1 CHALLENGES

CHALLENGES	SOLUTIONS
HEATING ACTIVATION IN AIR CONTAINER	TO BE OPTIMIZED (LARGE-SCALE) IN PROGRESS
Overheating distortion	Plastic selection (HDPE, PP)
Particles/cassettes foaming	Water pre-processing
Decreased reaction rate etc etc	Lye optimization
ENTIRE SYSTEM TESTING	TO BE OPTIMIZED
FINAL DESIGN	TO BE PROPOSED

2 PROJECT GOALS

PHASE I PROTOTYPE PRODUCTION

MILESTONE 1 Production optimization for activated Al particles/cassettes

MILESTONE 2 Alkaline additive optimization to support hydrogen generation

MILESTONE 3 Assembly/ testing / adjustment of H_2-generating container

PHASE II ECONOMIC EVALUATIONS / MARKET OF APPLICATIONS

MILESTONE 1 Assessment of the production costs

MILESTONE 2 Market of portable hydrogen storage containers

PRE - PROTOTYPE