



***New Green Hydrogen Fuels, The New  
Way Out from The Old CO2 Crisis...***

Marnix ten Kortenaar, CEO Dr Ten



## Dr Ten...

- Dutch – Israeli innovation&production company in new water/energy products....
- Founded in 2008. 12 people
- Revenu 1 million euro annually
- Based in Wezep and Jerusalem
- Founded by Marnix ten Kortenaar
  - MSc in in battery electrodes
  - PhD TU in H2 Storage/Conversion (with shell on side)
- Biggest hit so far the seasalt battery.....
- Setting more R&D/pilot projects in new green fuels....



## Innovators from the Netherlands and Jerusalem....



Government of the Netherlands



(pictures left from google)



Back up energy storage

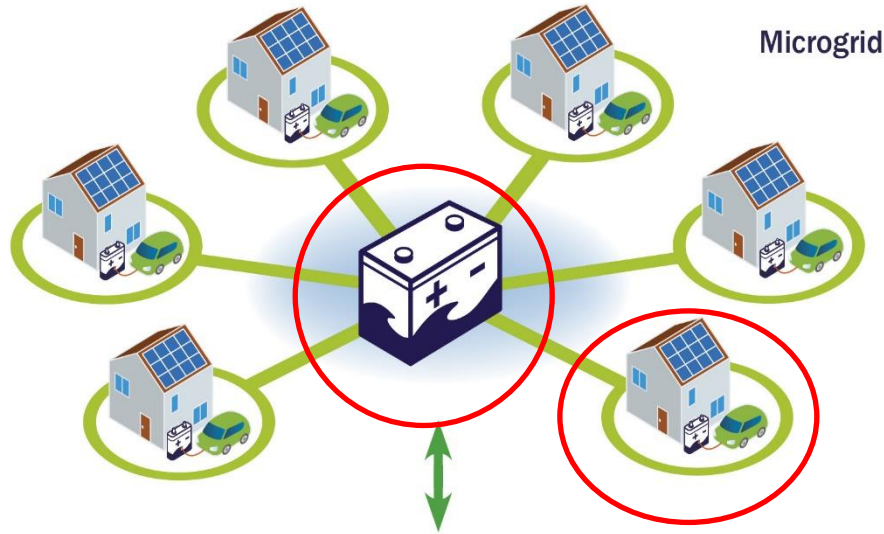
**Unique battery as:**

- **Broad temperature window**
- **Long lifetime, 64000 cycles**
- **100% discharge possible**
- **Made from seasalts, graphites**
- **Dc dc charge with solar panels**
- **Low cost materials**
- **Green materials**
- **Cradle to cradle recycling**



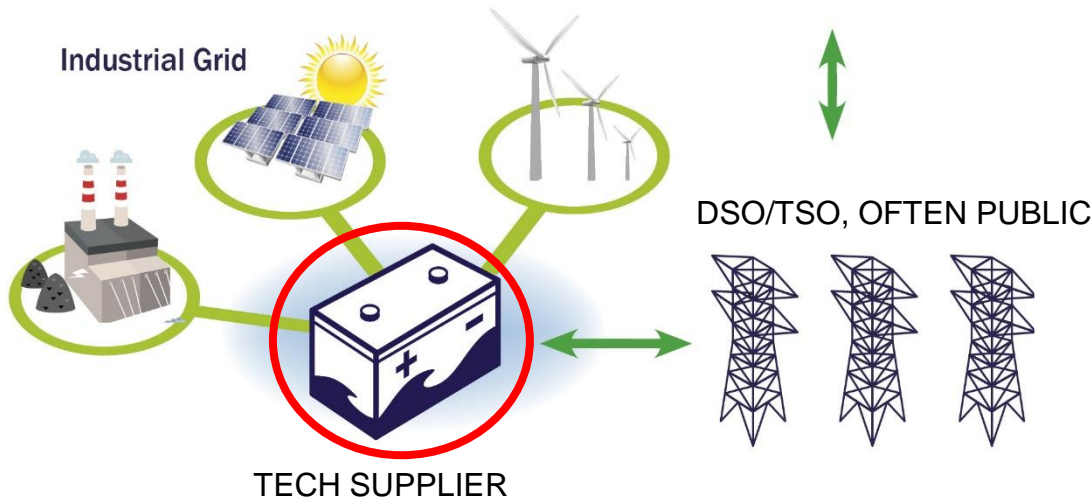


# Storage Systems

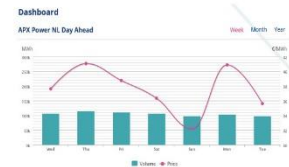


**Seasalt Battery**  
clean and cheap energy storage

- more electric vehicles
- reliable electricity
- more renewable energy
- lower cost for all
- no grid reinforcement needed



## APX Stock Exchange





# Characteristics

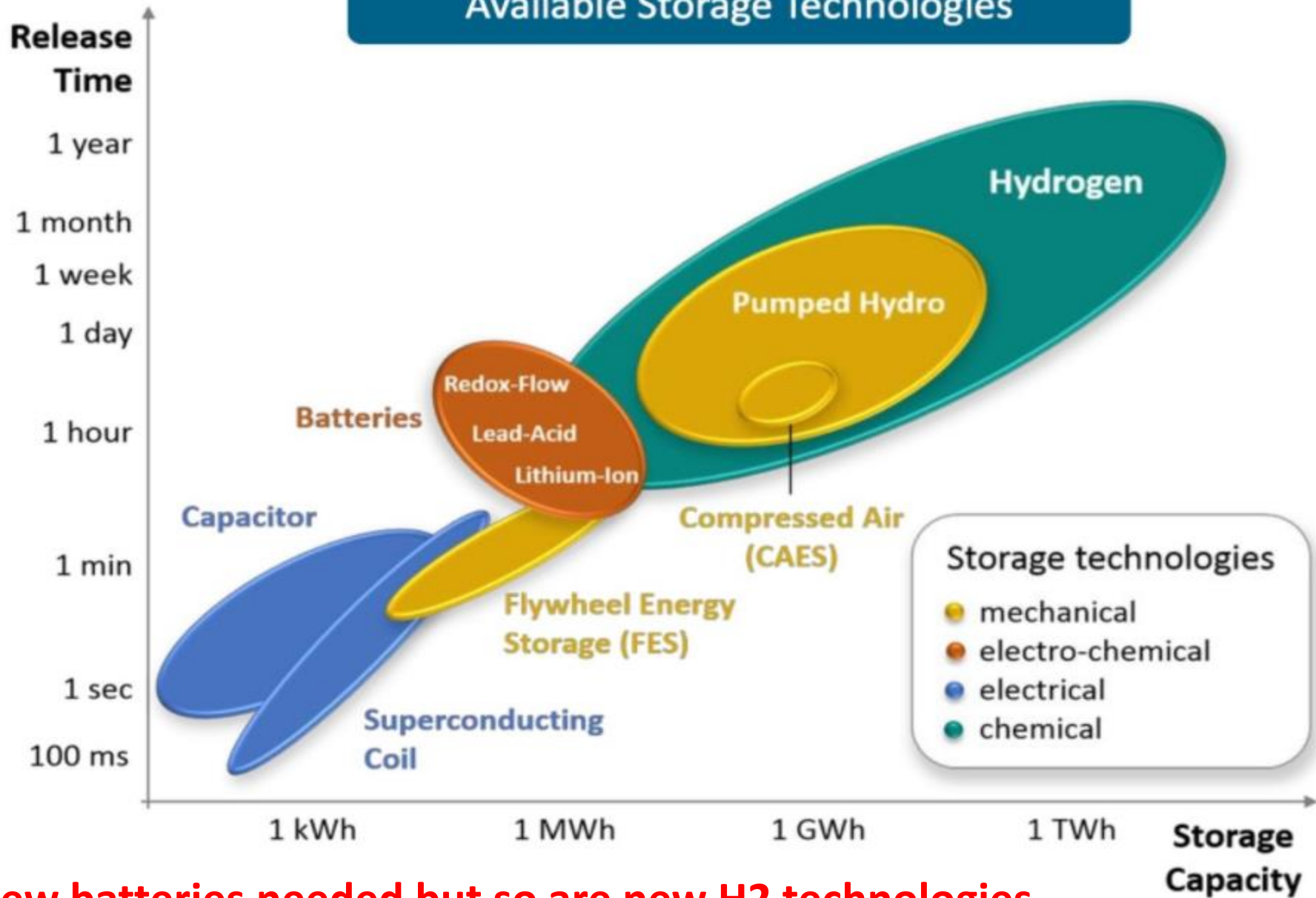
Battery estimates	Wh/kg	Wh/l	Cycles	€/kWh buying	€cent / kWh / Charge Cycle	Safe	Toxic	Minerals €/kg	Discharge	Complex BMS Need	Temp Use / C
<b>Stationary batteries</b>											
Lead Acid	20 (50% use)	80	1000	200	20	-	-	2.5	50%	yes	min. 20>50
Flow ZnBr2	50	55	4000	600	15	+/-	+/-	2.5	90-100%	no	min. 10 till 50
Flow Vanadium	20	30	10000	1400	14	-	-	400	90-100%	no	min. 5>55
SeaSalt	35	50	64000 (labtest, no end seen)	175 (mass-production)	2,5	+	+	0-2	90-100%	no	min. 30 > 80
<b>Mobile batteries</b>											
Lithium	60 (50% use)	100 (50%)	2500	800	32	-	-	400	50%	yes	0 to 50



## What was and is expected....

Year	kWh	Price euro/kWh	kWh/kg	Charge Cycle Price euro/kWh
2014	0,005	500000	10	500
2015	0,05	100000	14	10
2016	0,5	50000	18	2,5
2017	5	10000	22	1
2018	15	5000	26	0,5
2019	40	3000	30	0,25
2020	100	1500	35	0,10
2021-2025 > Mass product	5000	100-500	70	<0,01

# Available Storage Technologies



**New batteries needed but so are new H2 technologies...**





# The new CO<sub>2</sub> - H<sub>2</sub> challenge...

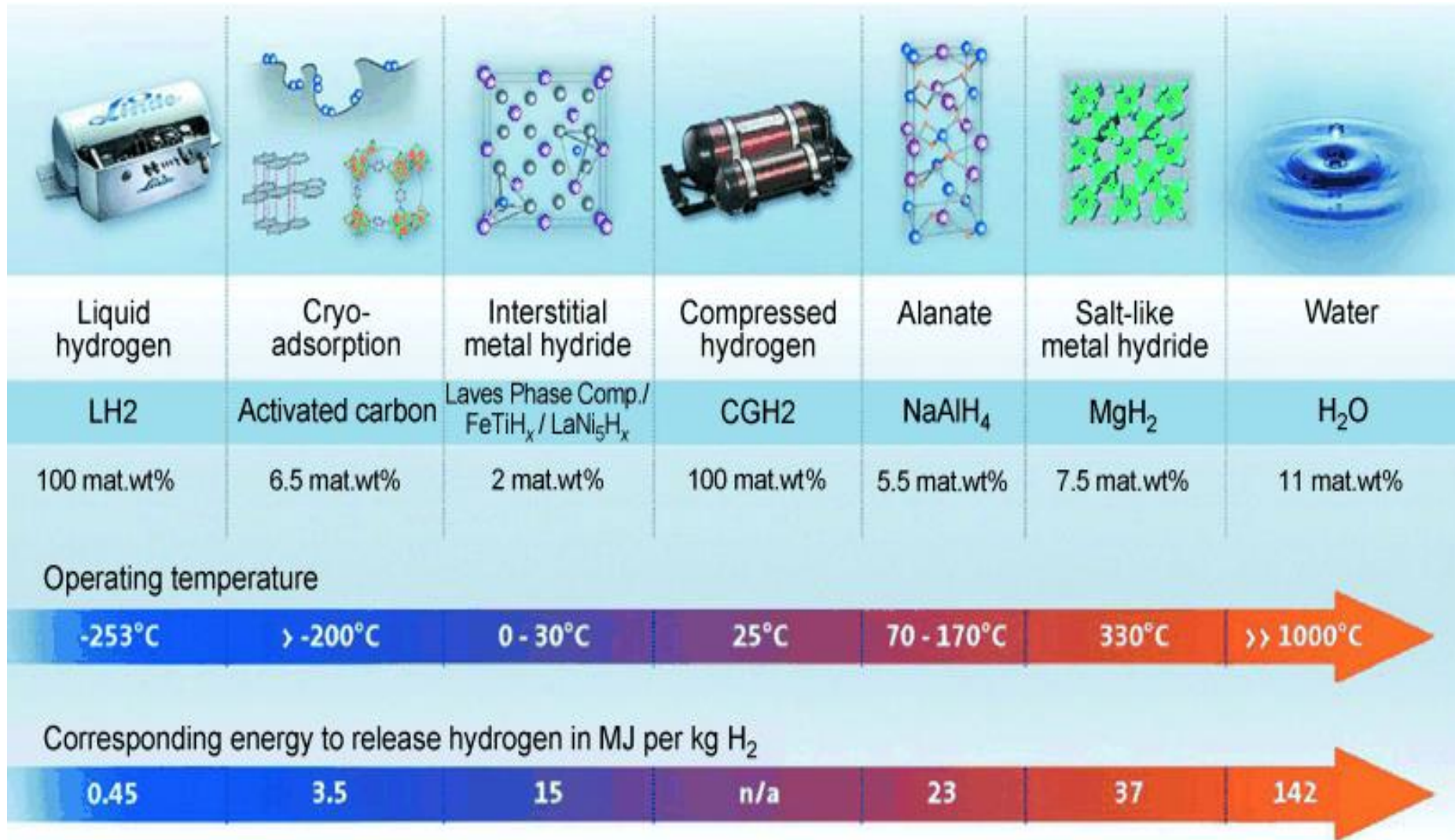


**CO<sub>2</sub> pollutes, H<sub>2</sub> is great but also needs to be:**

**1. Created....2. Stored....3. Converted....**

**Each step has costs and a loss of efficiency....**

**So people call for smart new H<sub>2</sub> green fuels...**



Several hydrogen storage technologies and their operating conditions.

**Not ideal yet any other green H2 containing fuels...**

(picture from Hebrew University of Jerusalem)



# New Dr Ten H<sub>2</sub>O<sub>2</sub> Fuel Cell - green fuel from H<sub>2</sub>/O<sub>2</sub>...



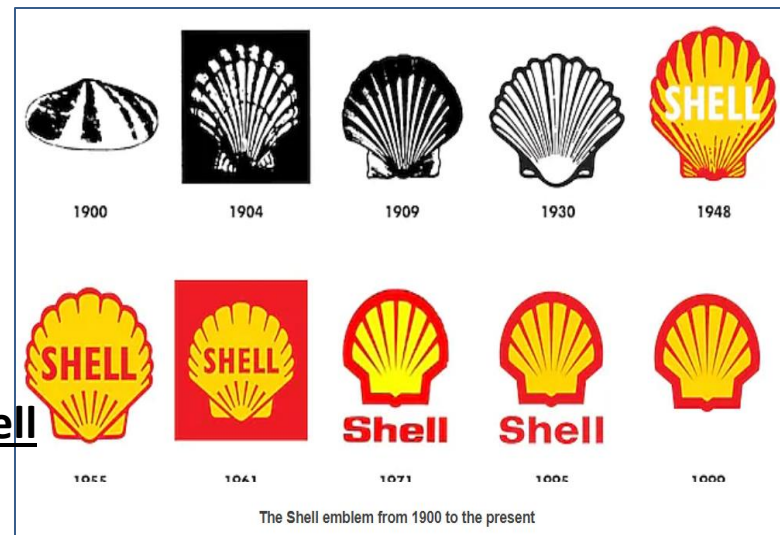
**Figure 8.1 E-Scooter [79]**





# An old CO2 solution, the Jacob shell....

In 1833, mr Samuel decided to sell seashells....  
Massive import of shells from the east followed  
setting world's world's biggest energy company...



(picture from google)





# From CO2 to seashells to oil....

**Carbon dioxide, shell building, and ocean acidification**

$\text{CO}_2$  Carbon dioxide

$\text{CO}_2 + \text{H}_2\text{O} \leftrightarrow \text{H}^{+1} + \text{HCO}_3^{-1}$

Carbon dioxide dissolves in the ocean and reacts with water to form carbonic acid—which in turn generates bicarbonate, carbonate, and hydrogen ions.

Hydrogen ion (proton)

Bicarbonate


$\text{HCO}_3^{-1} \leftrightarrow \text{H}^{+1} + \text{CO}_3^{-2}$

Bicarbonate

Hydrogen ion

Carbonate ion

◀PLAY AGAIN NEXT▶



Seashell -  $\text{CaCO}_3$  /  $\text{Ca}(\text{HCO}_3)_2$ .....

(picture from google)





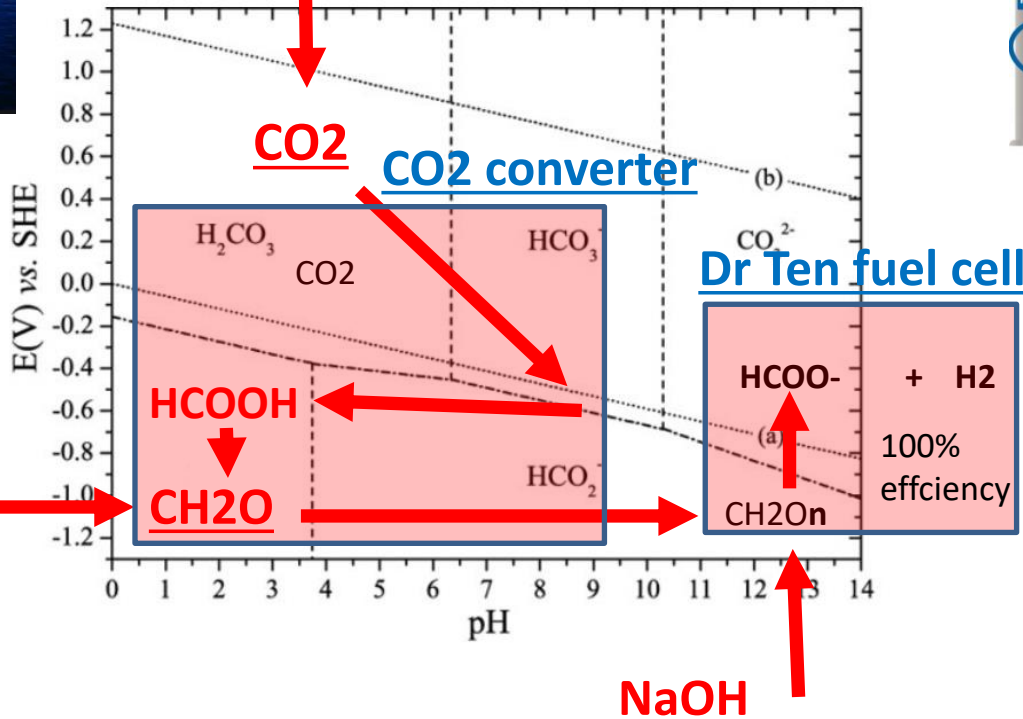
## Renewable H<sub>2</sub> fuels in study at Dr Ten...

- Formic acid (HCOOH)
- **Formaldehyde (CH<sub>2</sub>O<sub>n</sub>)**
- **Sodiumbicarbonate (NaHCO<sub>3</sub>)**
- **Hydrogen-(peroxide)-oxygen (H<sub>2</sub>/H<sub>2</sub>O<sub>2</sub>/O<sub>2</sub>)**
- **Glycerol (C<sub>3</sub>H<sub>6</sub>O<sub>2</sub>)**
- Methanol (CH<sub>3</sub>OH)
- Ethanol (C<sub>2</sub>H<sub>5</sub>OH)
- Ammonia (NH<sub>3</sub>)
- Borohydrides (NaBH<sub>4</sub>)

The **bold** ones enable more easy CO<sub>2</sub> to H<sub>2</sub>...

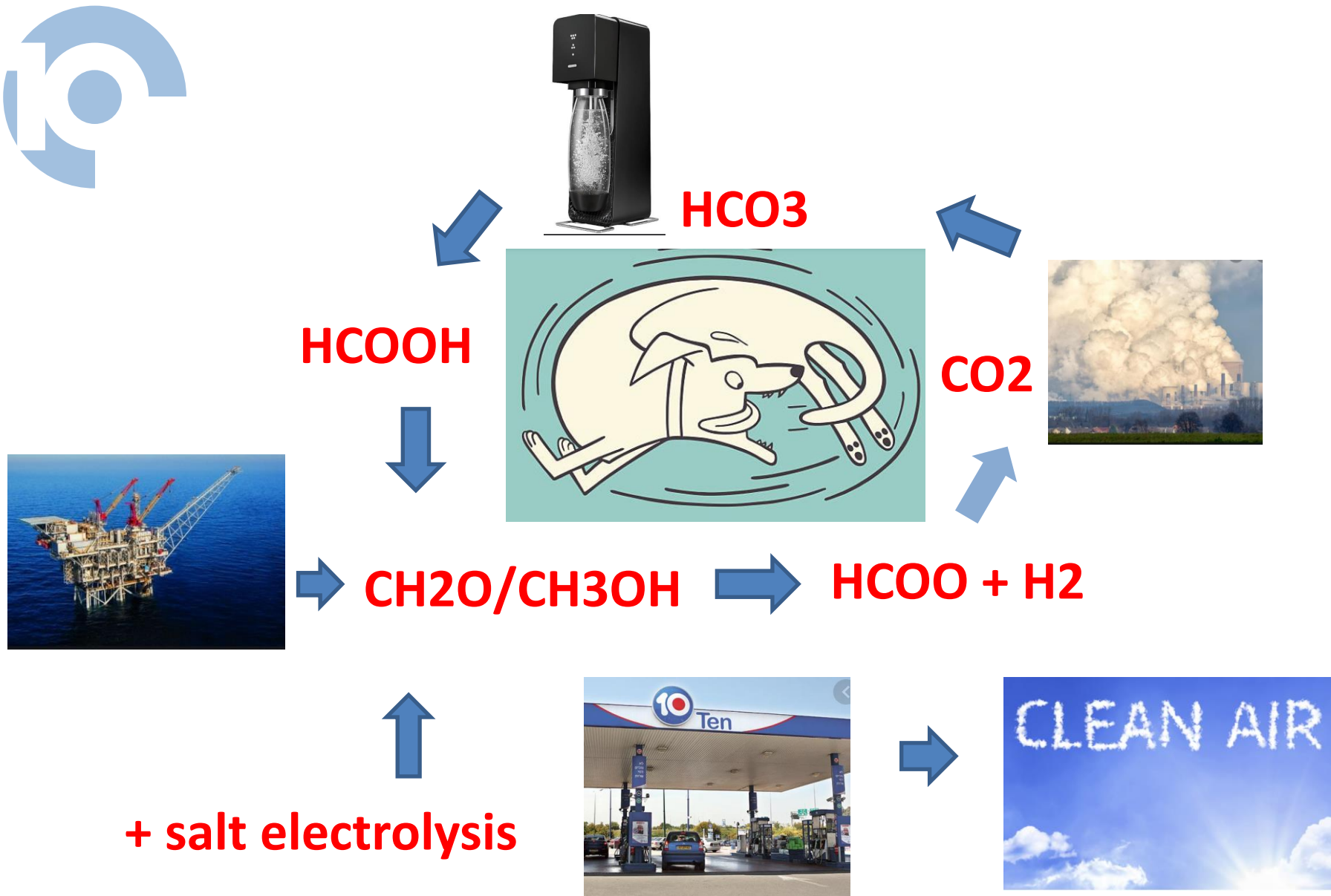


# A New H2 Road with solar/wind electricity, CO2, H2, CH4, CH3OH as feedstock....



**CH4 gas**  
 ↓  
Pyrolysis  
 $CH_4 \gg H_2 + Carbon$   
 ↓  
**CH3OH**

(photographs from google)



(picture from google)



## CH<sub>2</sub>O<sub>n</sub> >> H<sub>2</sub> + HCOO-...

- Liquid fuel for cars
- No change of gasoline stations
- CO<sub>2</sub> reduction possible
- CO<sub>2</sub> / CH<sub>4</sub> / CH<sub>3</sub>OH as feed stock possible
- Combination with salt factory possible
- Combination with Dr Ten's seasaltbattery / H<sub>2</sub>-O<sub>2</sub> technologies possible....



# Is the victory on CO2 still hidden in the shell of Jacob?



**At Dr Ten in Israel we believe so....**

(picture from google)



Thank you....

# International Israel-Eu/Dutch collaboration

