

**Waste-to-Hydrogen: A third pathway to renewable hydrogen production**

# So we have waste...

## Waste – unfortunately – is a truly renewable resource

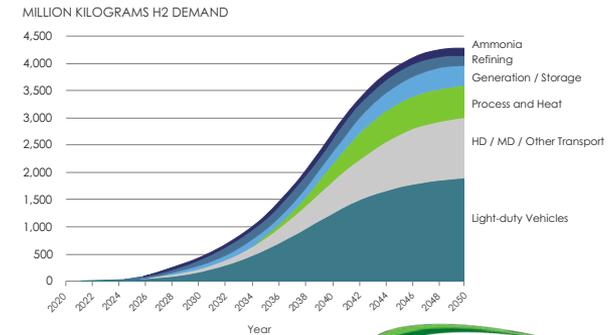
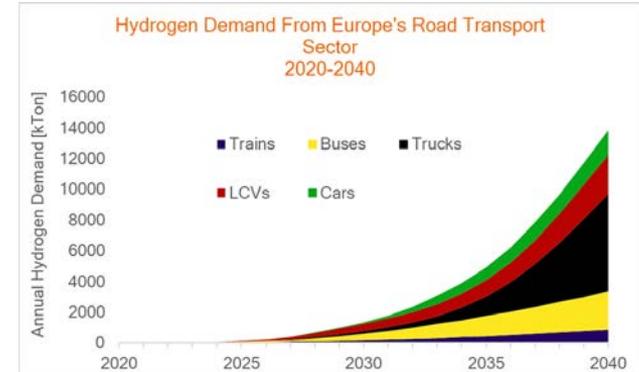
- 8 Billion Tons of Plastic Waste on Earth
  - In the ocean
  - In the ground
  - Even in our bodies !
- 240 Million Tons Unprocessed Plastics Added Each Year
- 2 Billion+ Tons Mixed Waste Buried Each Year into Landfills



# ... and hydrogen is coming

## Not an “if”, but a “when”

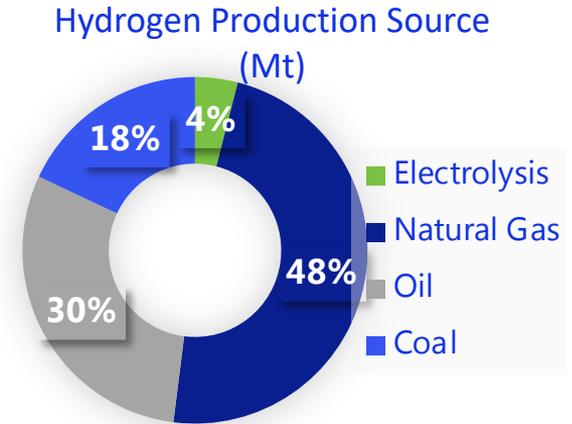
- 2MT H<sub>2</sub> demand in Europe, in 2030, for transportation only
- California leading the pack in North America, expected to reach 500,000 T H<sub>2</sub> demand by 2030
- Public transportation projects, automotive manufacturers, heavy duty vehicles...



# Hydrogen is still primarily fossil based

## Current world production: 50 M Tons per year

- Mostly used for crude oil refining or ammonia production
- Overwhelmingly fossil source  
(not unlike the power that charges our “clean” BEVs)



## Renewable Hydrogen pathways

- RE-based electrolysis is the most widely acknowledged RH<sub>2</sub> production solution
- What about biomass and waste ?

## Improving Waste management, producing clean Hydrogen

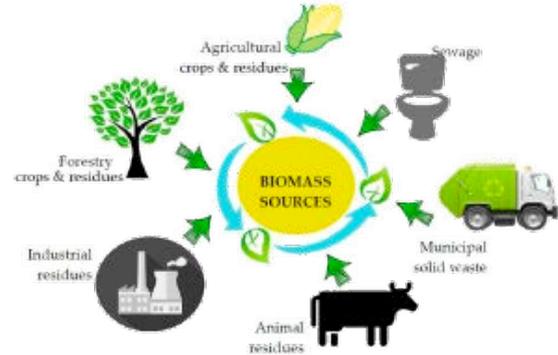
- Predictable, continuous and creatively solve another major environmental issue
- Small size distributed systems improve waste logistics and provide a clean decentralized conversion of waste to energy.
- Cleaner than incineration, addresses landfill diversion mandates



# Biomass & Waste: the third pathway

## Billion-Ton Report - U.S. Energy Department & Oak Ridge National Lab

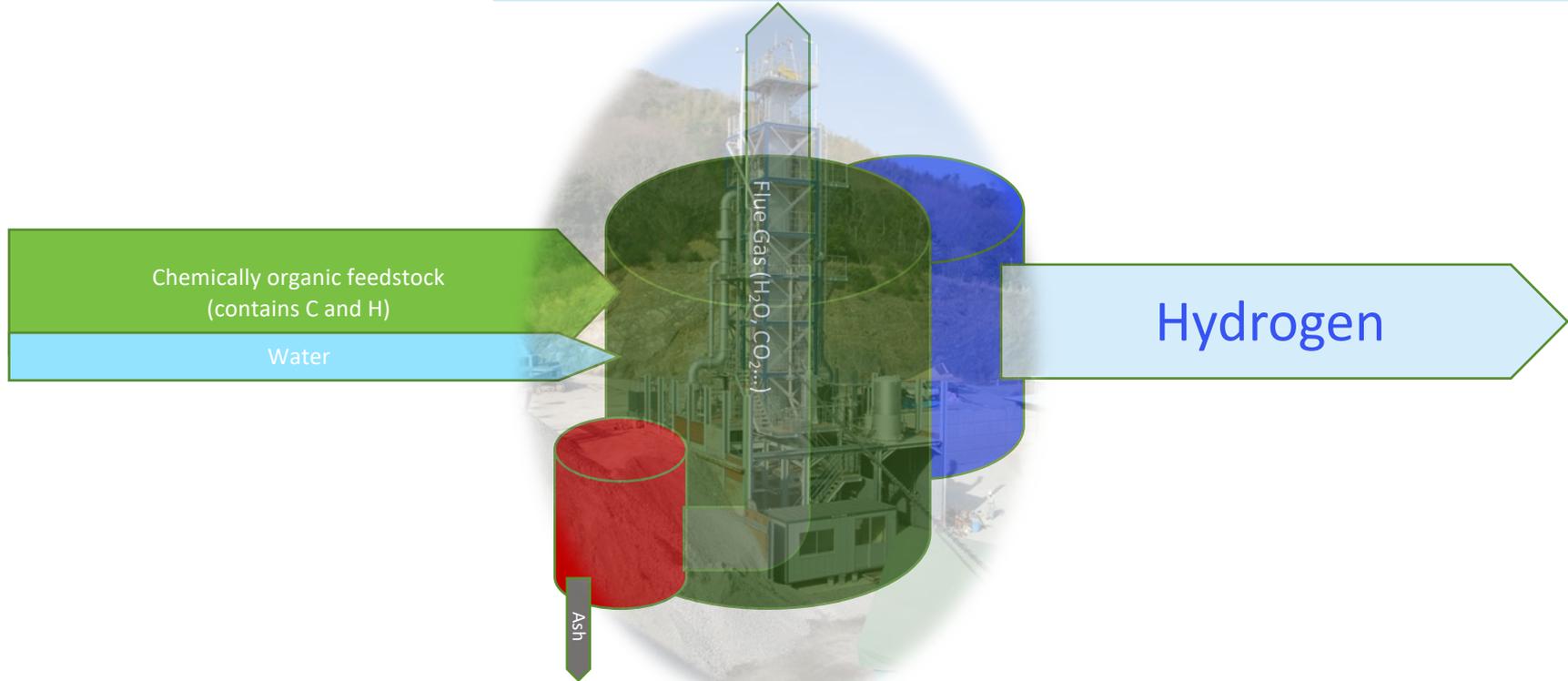
- A real source for hydrogen production:
  - 1 billion ton biomass = 50 M tons H<sub>2</sub>,
  - 50 M tons of H<sub>2</sub> contains enough energy to replace 90% of U.S. annual gas consumption of 3.4 billion barrels



## Plastics are truly hydrogen-rich

- Only a fraction is truly recyclable:
  - 240 M ton plastics = 20 M tons H<sub>2</sub>,
  - 20 M tons of H<sub>2</sub> contains enough energy to replace 36% of U.S. annual gas consumption of 3.4 billion barrels





# Pathway to true carbon negativity

Renewable electricity electrolysis and conventional biofuels are merely carbon neutral.

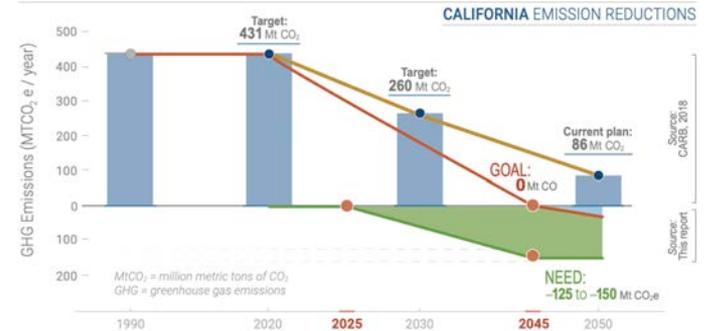
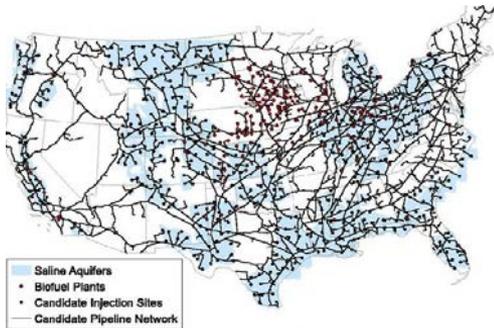
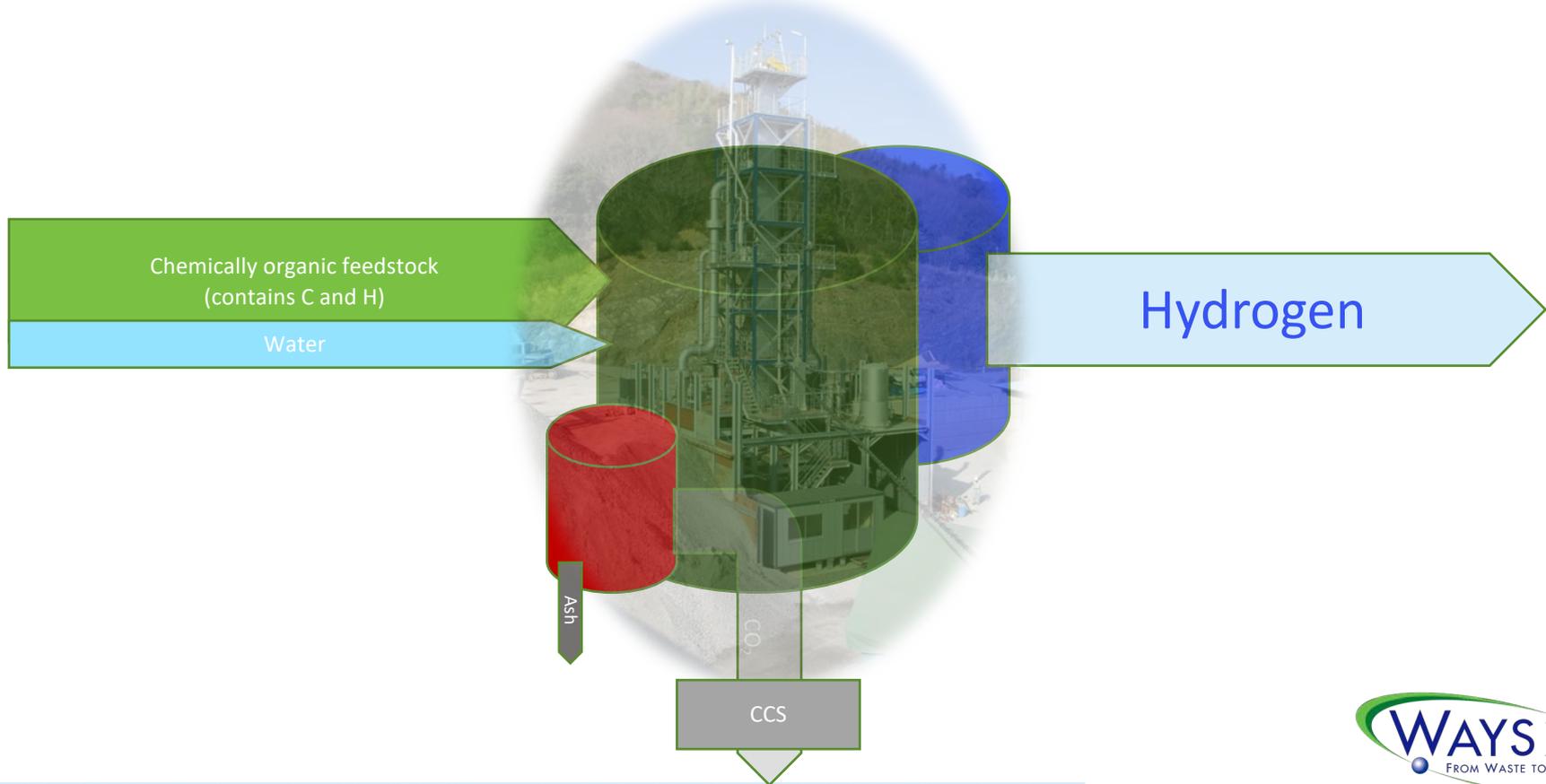


Figure ES-1. Goals of California's emissions plan extrapolated to 2045 (CARB, 2017) with negative emissions estimates from this report.



Hydrogen (or Power) from Biomass and Waste: Effectively remove carbon from the atmosphere by combining conversion stations with CCS technology.

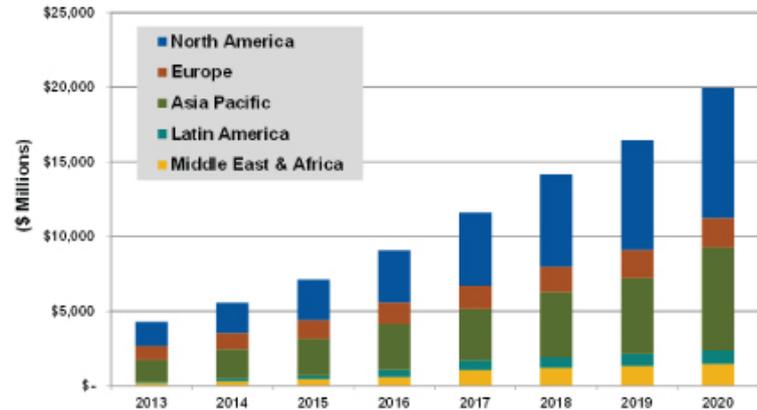


## Power microgrids are a growing reality

- Demand for baseload distributed power generation & storage
- Need for new technologies for resilience & to support more solar + distributed energy resources on the grid
- The basis for CCA programs

## Clean Fuel stations (US):

- Hydrogen: 61
- EV public charging 78,301 (outlets)
- Gasoline stands: 110,000



Microgrid vendor revenue is expected to nearly triple by 2020 as concern about conventional grid vulnerability grows while the cost of energy storage and renewable energy infrastructure decline

<https://ensia.com/features/the-emerging-power-of-microgrids/>

## Utility models

- 50M tons H<sub>2</sub> per year from the Billion Ton biomass:
  - 120,000 24 tpd systems directly connected to fueling stations
  - H<sub>2</sub> and power supply from one station (FCEV, BEV)
- Shell USA: 13,000 stations / total of 110,000 nationwide
  - \$23Bn yearly Hydrogen sales assuming public price @ \$4/kg





**WAYS2H**  
FROM WASTE TO HYDROGEN

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