



## Sources of Zero Carbon Hydrogen

*Part of the Hydrogen Tech Brief Series*

# The Energy Transition

*In the past  
both our electricity and hydrogen came from fossil sources  
in the future, neither will*

# Why Hydrogen?

- Hydrogen is an alternative form of renewable electricity
  - Electricity can be easily converted to hydrogen
    - Splitting water molecules into hydrogen and oxygen using electricity
  - Hydrogen is easily converted to electricity
    - Hydrogen and oxygen (from the air) create electricity in a fuel cell
- Hydrogen is a portable and storable form of Renewable Electricity

# Why Do We Need Hydrogen?

*Hydrogen Can Do More than the Grid and Batteries Alone*

	Energy Source	Energy Carrier	Storability		Fast Transfer to Vehicles	Steel, Cement Glass making	Long-Distance Energy Transport
			Short Term	Long Term			
Fossil Fuels	X	X	X	X	X	X	X
Wind & Solar	X						
Electric Grid		X					X
Batteries		X	X				
Hydrogen	X	X	X	X	X	X	X

- Geological hydrogen
- Zero-carbon hydrogen from oil wells



# Sources of Zero Carbon Hydrogen

## Electrolysis

- Splitting water molecules with renewable electricity

## Hydrogen From Old Petroleum Wells

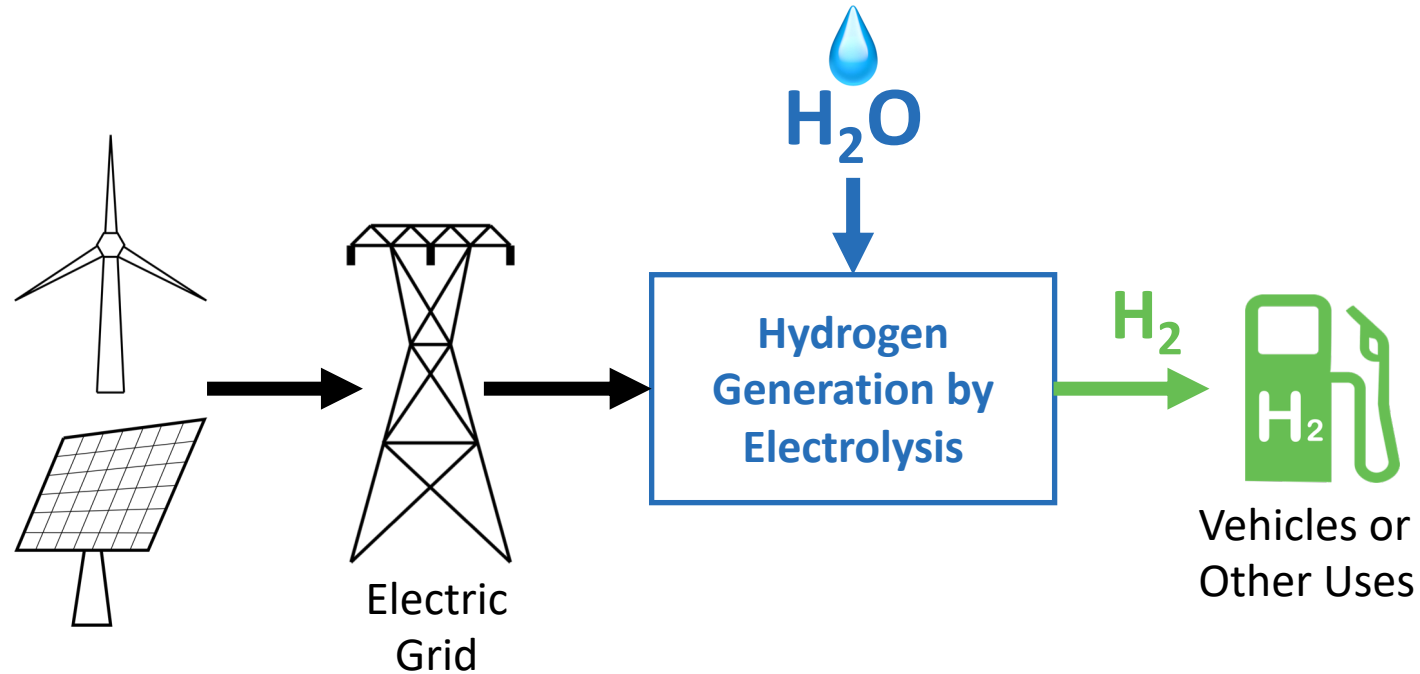
- Steam Methane Reforming underground and only hydrogen leaves the well

## Geological Hydrogen

- Hydrogen is naturally occurring underground
- An ongoing, renewable process

# Electrolysis

- Zero-Carbon hydrogen is generated using renewable electricity
  - In a device called an electrolyzer
- Can be performed at point-of-use or centralized locations



# Does Hydrogen Generation Use a Lot of Water?

- No. A medium-sized fuel station uses the same water as two homes

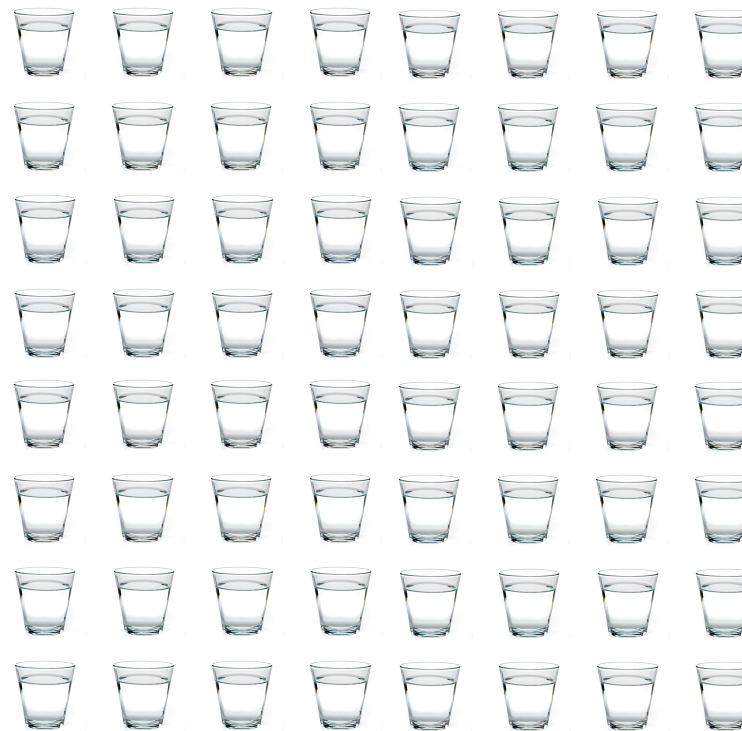
Typical Home  
90 Gallons/day



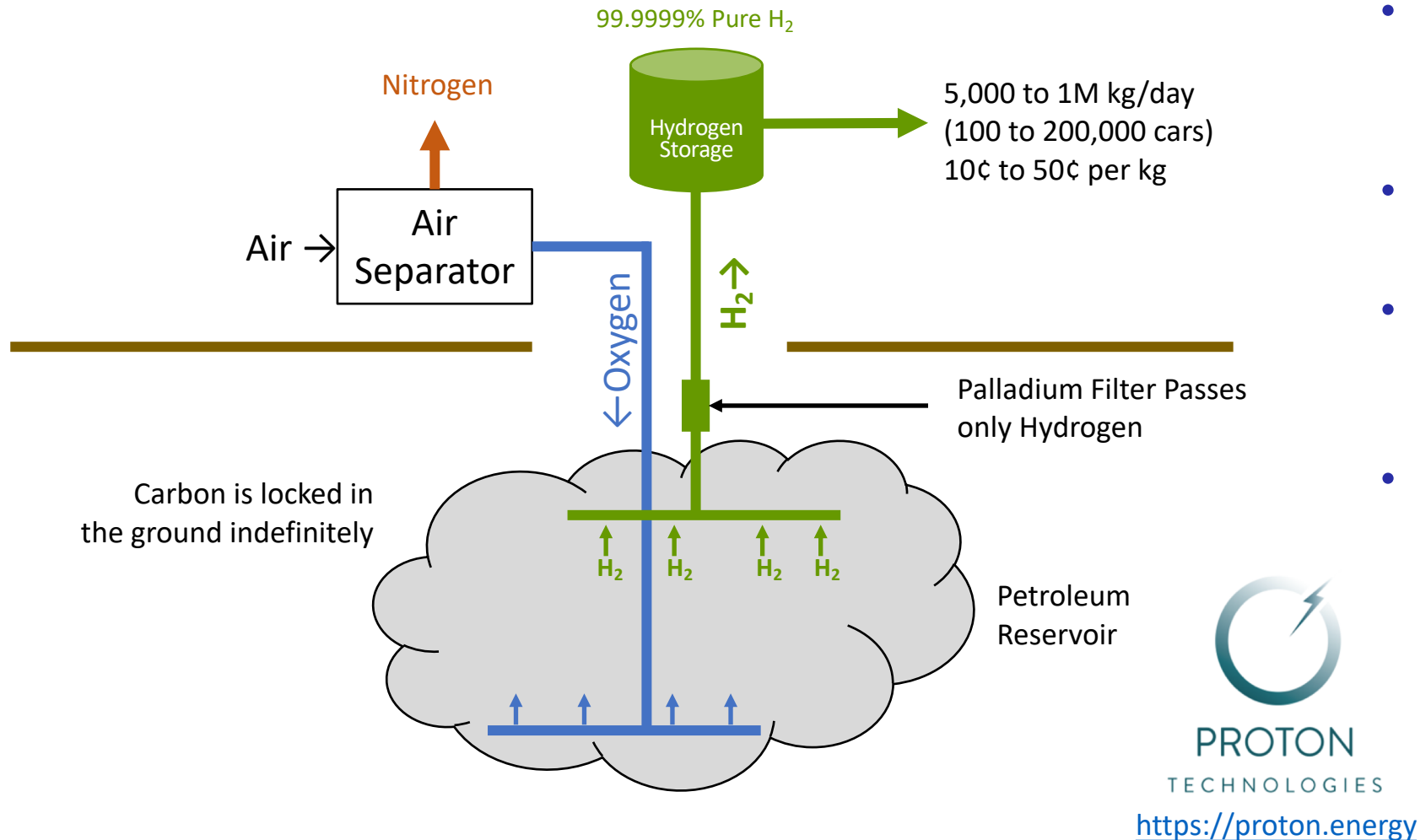
Hydrogen Station  
180 Gallons/day



Average Restaurant  
5,800 Gallons/day



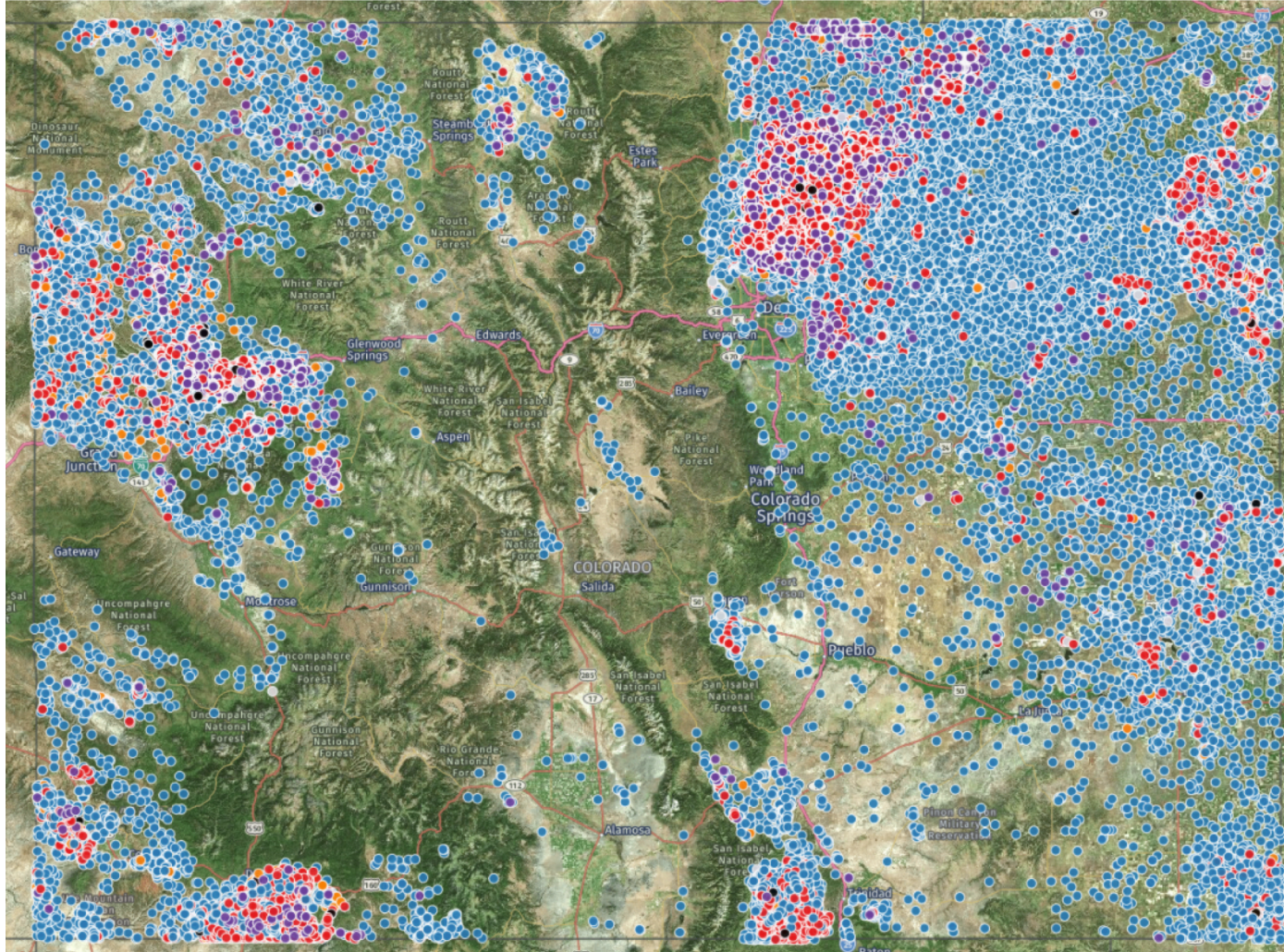
# Zero-Carbon Hydrogen from Petroleum Wells



- Oxygen is injected into wells to free the hydrogen
  - “Fire Flood” effect
- Hydrogen is generated underground
- Only Hydrogen is brought out of the well through a palladium filter
- Works well with abandoned, spent wells



# Petroleum Wells in Colorado



- Colorado has over 20,000 abandoned wells
- Many of the abandoned wells can be used to produce hydrogen
- Red are active  
Blue are abandoned

Source: <https://corising.org/colorado-map-oil-gas-wells/>

# Geological Hydrogen



- Naturally occurring hydrogen pockets exist all over the world
  - Renewable, via ongoing process
  - Recoverable with a simple well-bore
- Natural Hydrogen Energy, LLC was created to recover hydrogen from wells
  - Demonstration well in Nebraska between Lincoln and Hastings
- See paper at:  
<https://sci-hub.se/10.1016/j.earscirev.2020.103140>
- Project has been awarded the *Solar Impulse Efficient Solution* label, as a part of Thousand Solutions to Change the World

# Take-Away

- Hydrogen is an alternative form of renewable electricity
- To replace all the functions of fossil fuels, renewable electricity needs support from hydrogen
- Hydrogen can be a source of zero-carbon energy when derived from natural geological sources or extracted from petroleum wells