Role of EV and Hydrogen in transportation
to achieve Indonesia NZE aspiration by 2060

by

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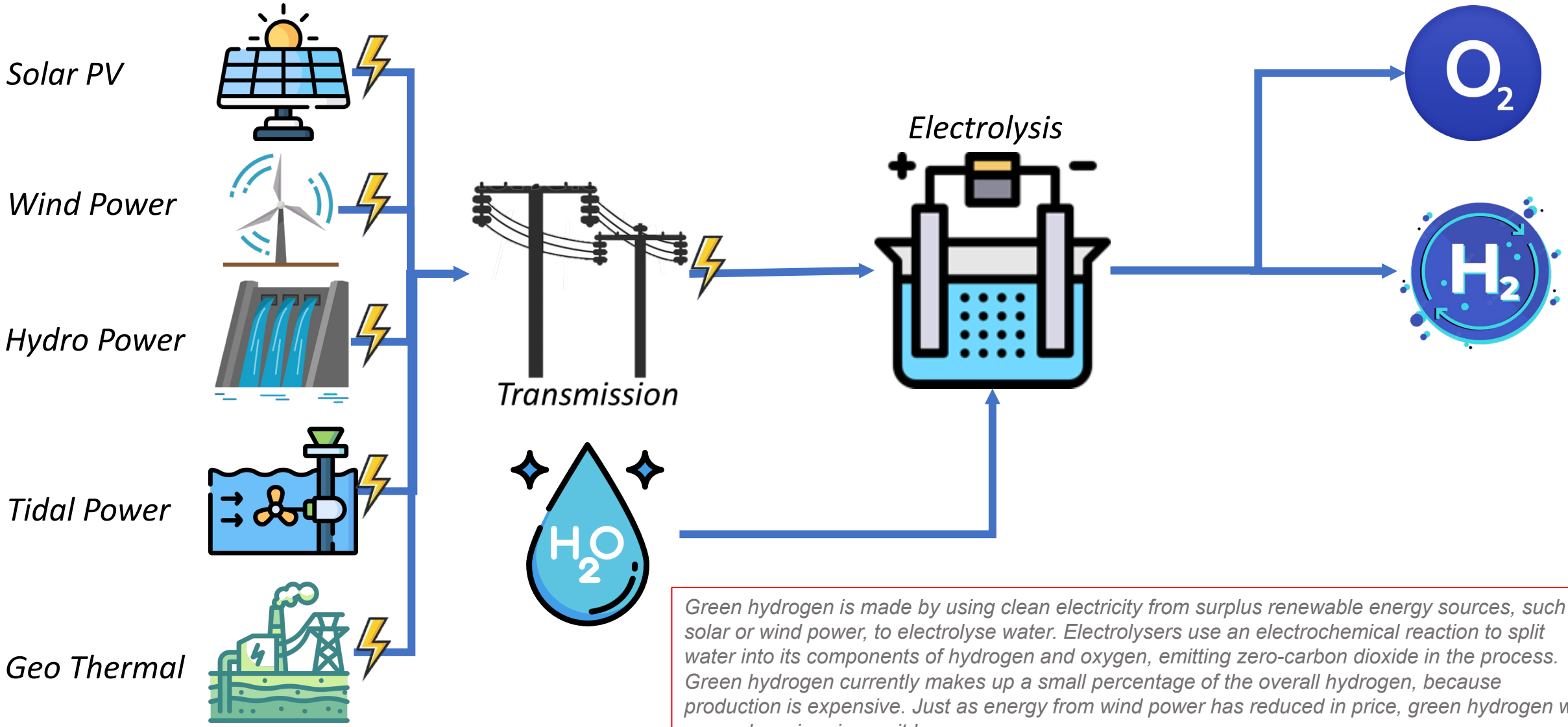
Why Hydrogen?

- *Hydrogen is a clean fuel that, **when consumed in a fuel cell, produces only water.***
- *Hydrogen can be produced from a variety of domestic resources: natural gas, nuclear power, biomass, renewable power like solar and wind*
- *In transportation, hydrogen can provide a zero-emission alternative to fossil fuel internal combustion engines.*
- *Hydrogen, either mixed with natural gas or burned alone, offers a less carbon intensive method to produce electricity.*
- *But, NOT ALL HYDROGEN ARE EQUAL* 

Which Hydrogen?

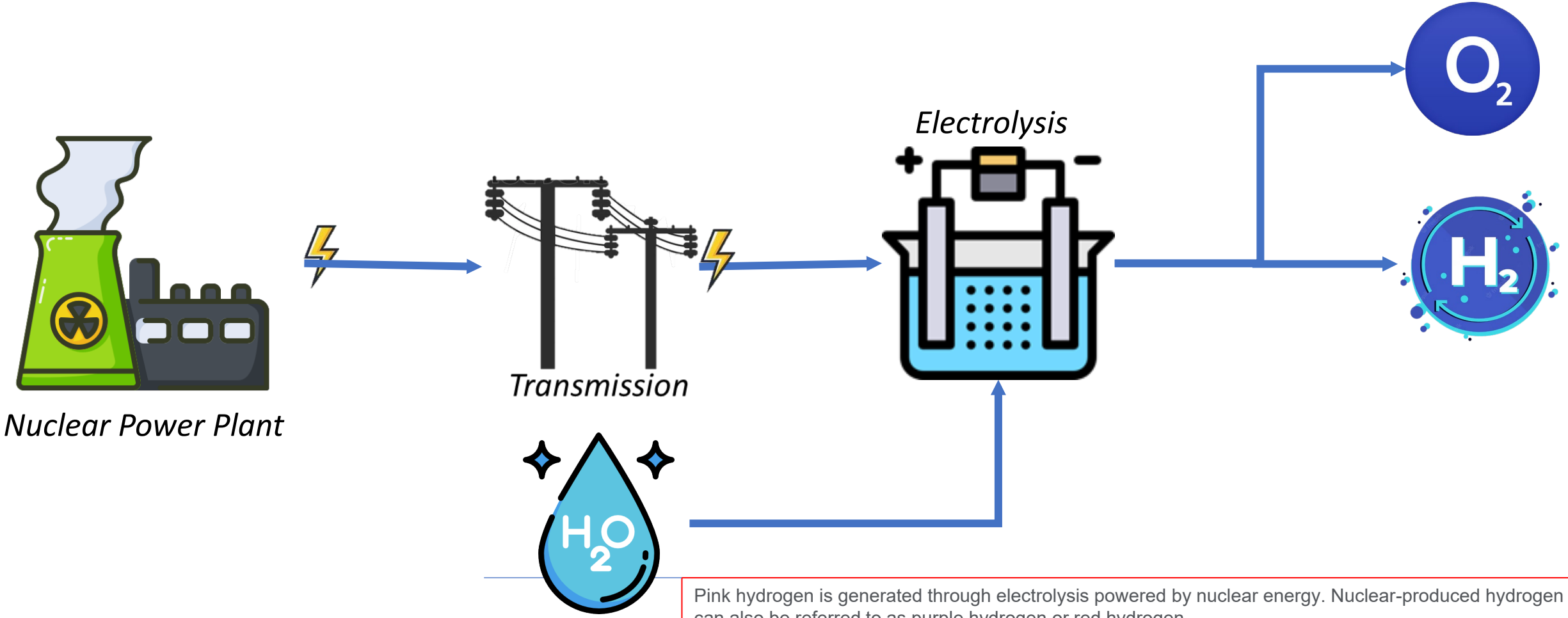
Green Hydrogen



Green hydrogen is made by using clean electricity from surplus renewable energy sources, such as solar or wind power, to electrolyse water. Electrolysers use an electrochemical reaction to split water into its components of hydrogen and oxygen, emitting zero-carbon dioxide in the process. Green hydrogen currently makes up a small percentage of the overall hydrogen, because production is expensive. Just as energy from wind power has reduced in price, green hydrogen will come down in price as it becomes more common.

Which Hydrogen?

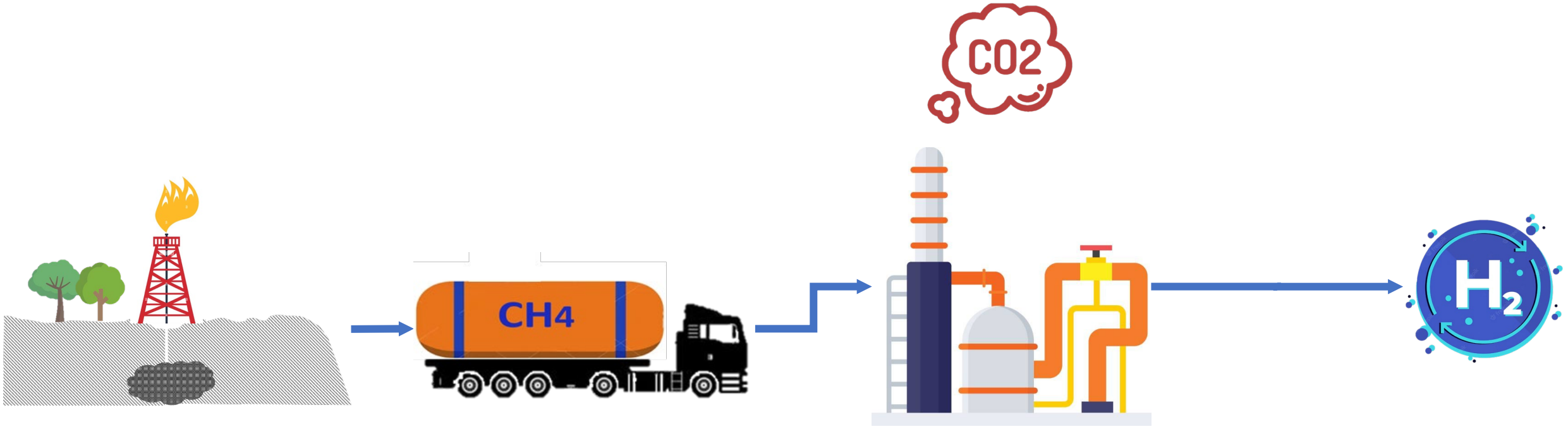
Pink Hydrogen = **Purple Hydrogen** = **Red Hydrogen**



Pink hydrogen is generated through electrolysis powered by nuclear energy. Nuclear-produced hydrogen can also be referred to as purple hydrogen or red hydrogen.
In addition, the very high temperatures from nuclear reactors could be used in other hydrogen productions by producing steam for more efficient electrolysis or fossil gas-based steam methane reforming.

Which Hydrogen?

Grey Hydrogen

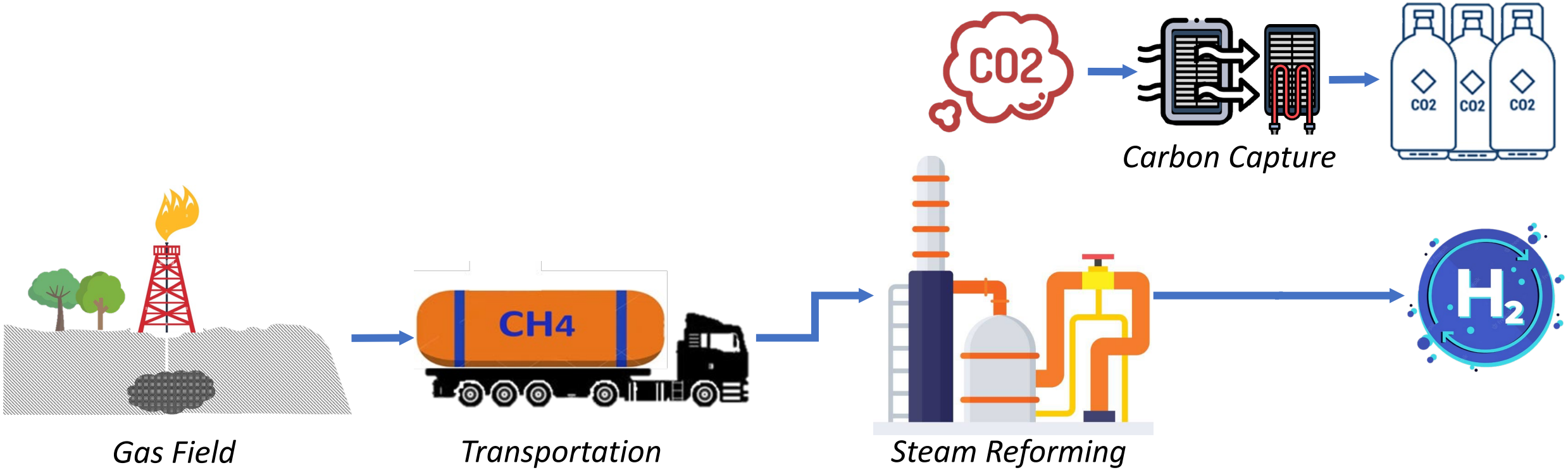


Gas Field *Transportation* *Steam Reforming*

Currently, this is the most common form of hydrogen production. Grey hydrogen is created from natural gas, or methane, using steam methane reformation but without capturing the greenhouse gases made in the process. Grey hydrogen is essentially the same as blue hydrogen, but without the use of carbon capture and storage.

Which Hydrogen?

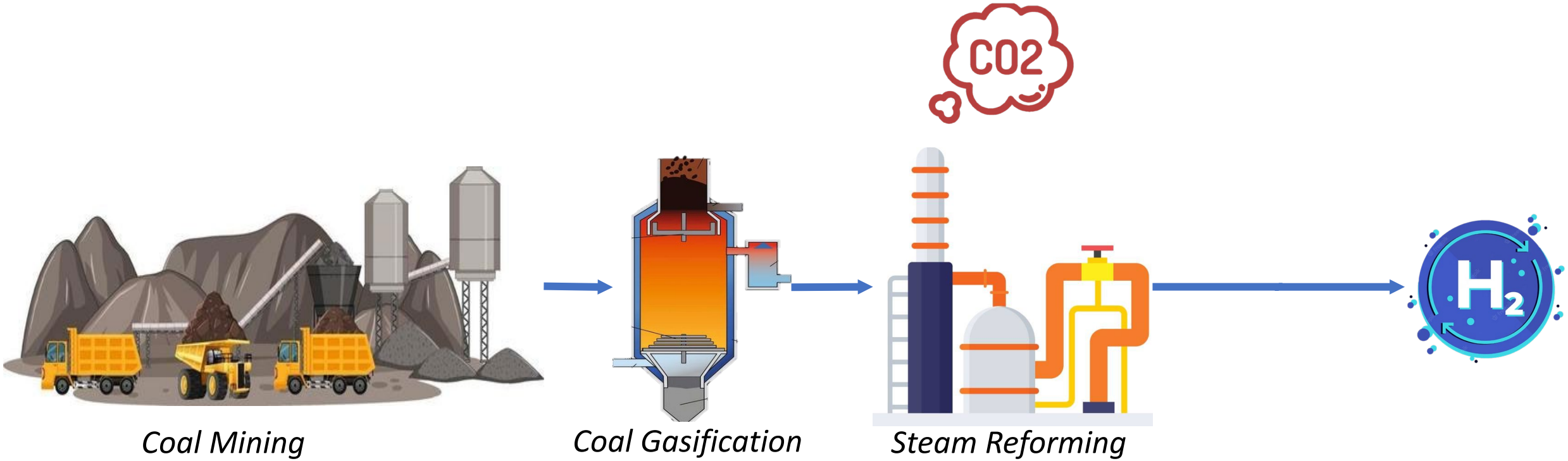
Blue Hydrogen



Blue hydrogen is produced mainly from natural gas, using a process called steam reforming, which brings together natural gas and heated water in the form of steam. The output is hydrogen, but carbon dioxide is also produced as a by-product. So, the definition of blue hydrogen includes the use of carbon capture and storage (CCS) to trap and store this carbon.
Blue hydrogen is sometimes described as 'low-carbon hydrogen', as the steam reforming process doesn't actually avoid the creation of greenhouse gases.

Which Hydrogen?

Black Hydrogen & **Brown Hydrogen**



Coal Mining *Coal Gasification* *Steam Reforming*

Using black coal or lignite (brown coal) in the hydrogen-making process, these black and brown hydrogen are the absolute opposite of green hydrogen in the hydrogen spectrum and the most environmentally damaging.
Just to confuse things, any hydrogen made from fossil fuels through the process of ‘gasification’ is sometimes called black or brown hydrogen interchangeably.
Japan and Australia announced a new brown coal-to-hydrogen project recently. This project will use brown coal in Australia to produce liquefied hydrogen, which will then be shipped to Japan for low-emission use.

Which Hydrogen?

Turquoise Hydrogen

- *This is a new entry in the hydrogen colour charts.*
- *Production has yet to be proven at scale.*
- *Made using Methane Pyrolysis Process to produce hydrogen and solid carbon.*
- *In the future, Turquoise Hydrogen may be valued as a low-emission hydrogen,*

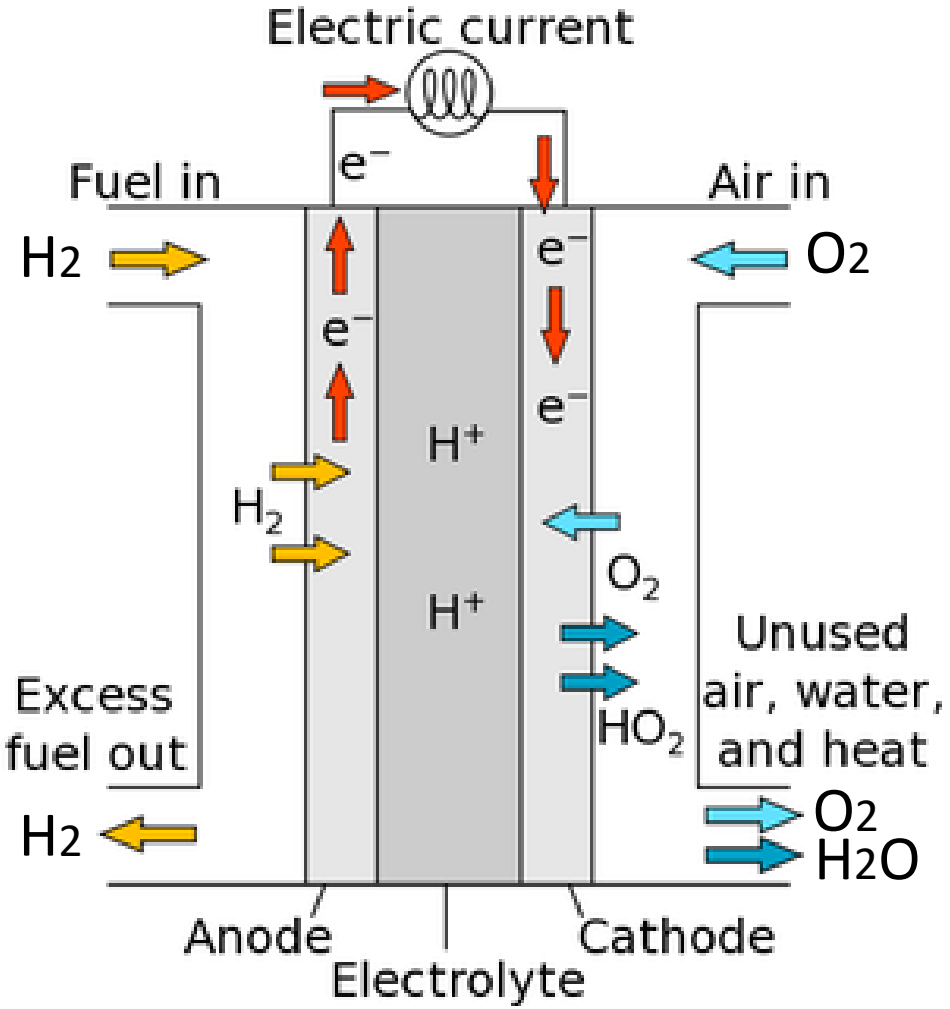
Yellow Hydrogen

A relatively new phrase for hydrogen made through electrolysis using solar power.

White Hydrogen

White hydrogen is a naturally occurring, geological hydrogen found in underground deposits and created through fracking. There are no strategies to exploit this hydrogen at present.

Fuel Cell



TOYOTA

HYUNDAI

H_2 ICE

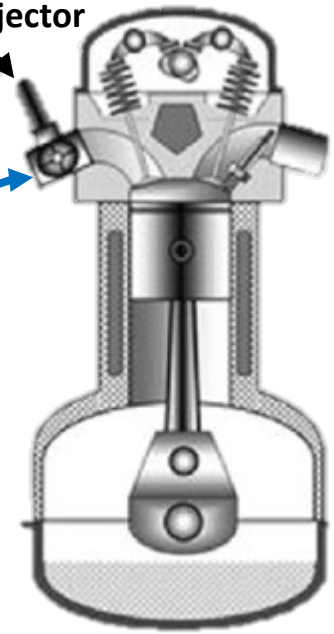
Liquid H_2 Tank

10,000 PSi

Liquid H_2 Pump

Expansion Chamber

H2 Injector



RENAULT

TOYOTA

e-Fuel, as another alternative

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PORSCHE

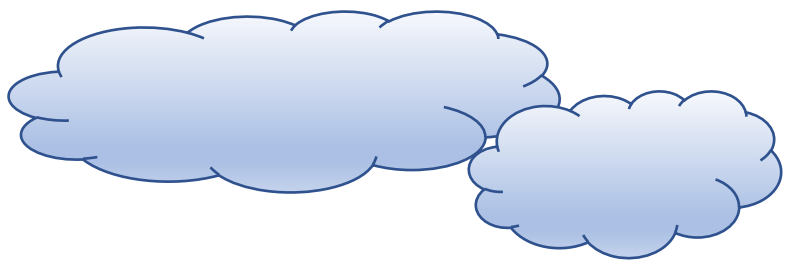
STUTTGART

$75 million

HIF®

Highly Innovative Fuel

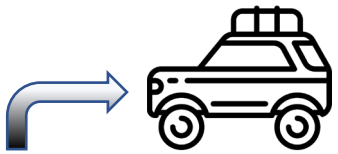
Carbon Capture



N_2

O_2

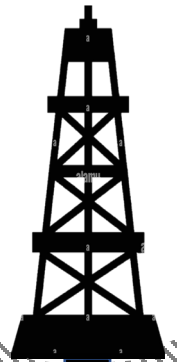
Etc.



$C_8H_{18} + O_2 \rightarrow \mathbf{CO_2} + H_2O$

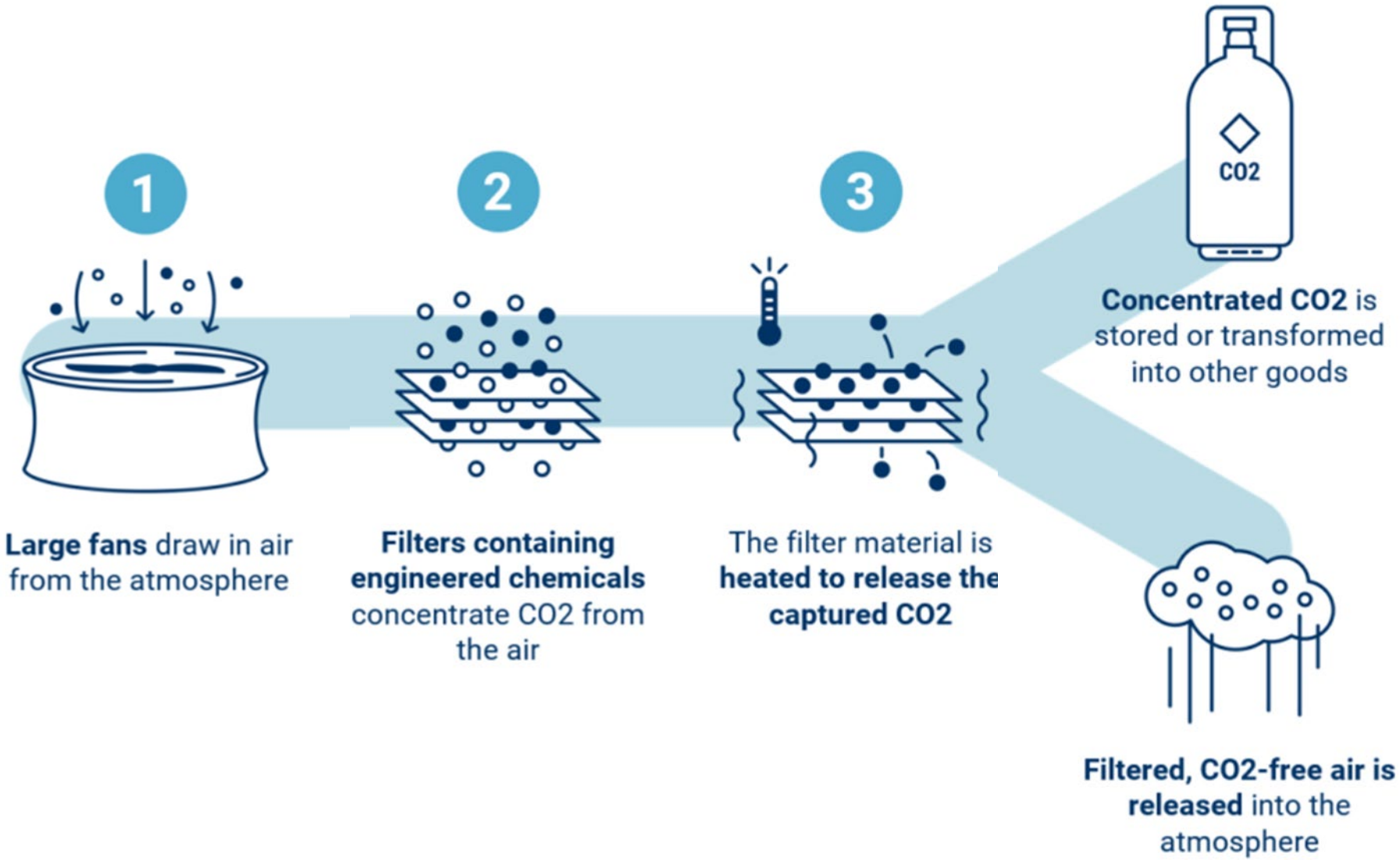
CO_2

CxHy

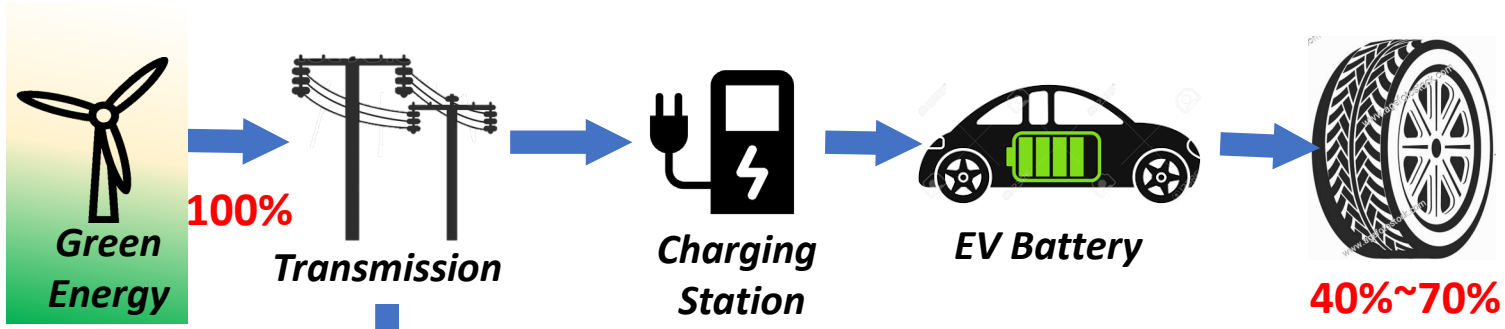


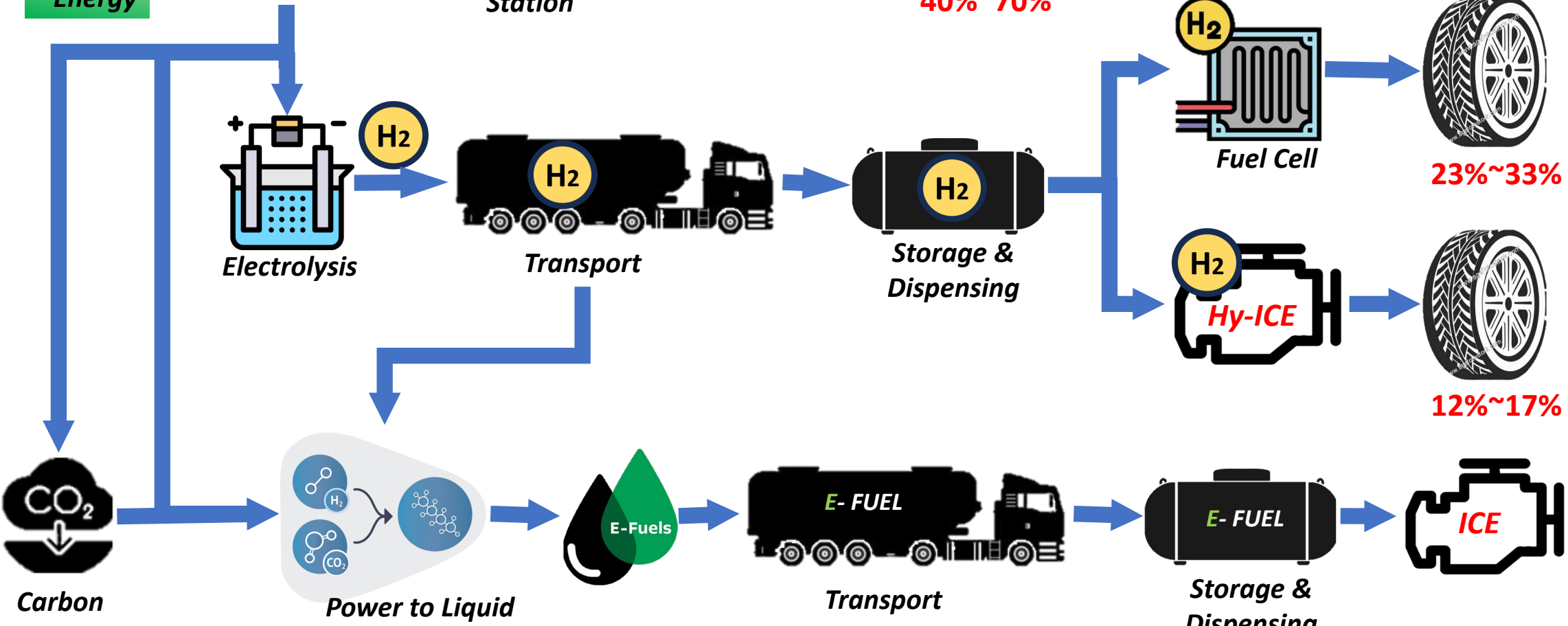
H_2O

Carbon Capture



BEV, Hydrogen & e-Fuel





Which is better for Transportation, Hydrogen or Battery EV?

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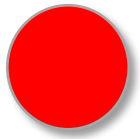
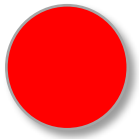
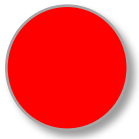
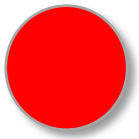
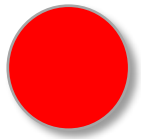
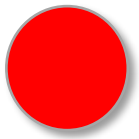
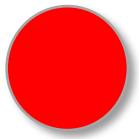
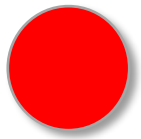
- ***All options are only good IF the energy source is Green energy / Renewable energy***
- ***We should look from the final "Usable" energy (=energy that is available to be used by the vehicle)***
  The available usable energy:
  - *In Battery Electric Vehicles is between **40% to 70%***
  - *In Fuel Cell Electric Vehicles is between **23% to 33%***
  - *In Hydrogen-Internal Combustion Engine Vehicles is between **12% to 17%***
  - *In E-Fuel with Normal-Internal Combustion Engine Vehicles is between **6% to 18%***
- ***Vehicle's cost:***
  - ***BEV** more expensive than regular ICE vehicles, but cheaper than FCEV*
  - *With battery cost per KWh is getting cheaper, BEV is becoming less expensive than Hy-ICE*
- ***Infrastructure:***
  - *For BEV, all households connected to power grid can be charging stations*
  - *Hydrogen infrastructure is not developed yet*
  - *E-Fuel infrastructure is using existing fuel distribution system, except for the **Carbon Capture** and **Power-to-Liquid** facilities.*
- ***Exhaust Emissions:***
  - ***BEV & FCEV** is the best, BEV no tail pipe emissions, FCEV emits water*
  - *Hy-ICE & E-Fuel still have NOx from their tail pipe (e-Fuel has all sort of other emissions, eg: Unburned Hydrocarbon)*

Which is better for Transportation, Hydrogen or Battery EV?

	Vehicle Price	Infra Structure	Tailpipe Emissions	Energy Efficiency
BEV				
FCEV				
Hy-ICE				
E-Fuel				

With BEV vehicle price and Charging infrastructure is getting better every day, plus so much energy wasted if we use Hydrogen as an energy source for transportation, Battery Electric Vehicle seemed to be still the best option.

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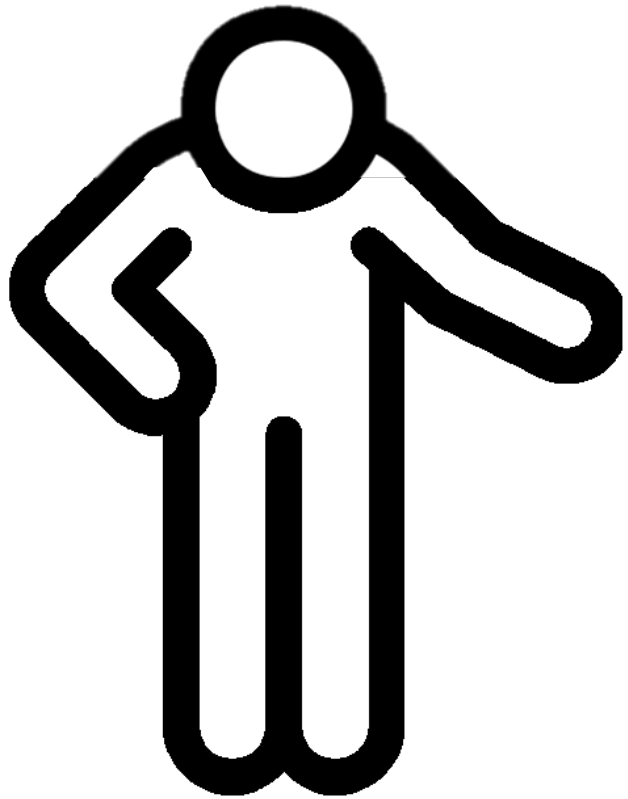

Thank
You