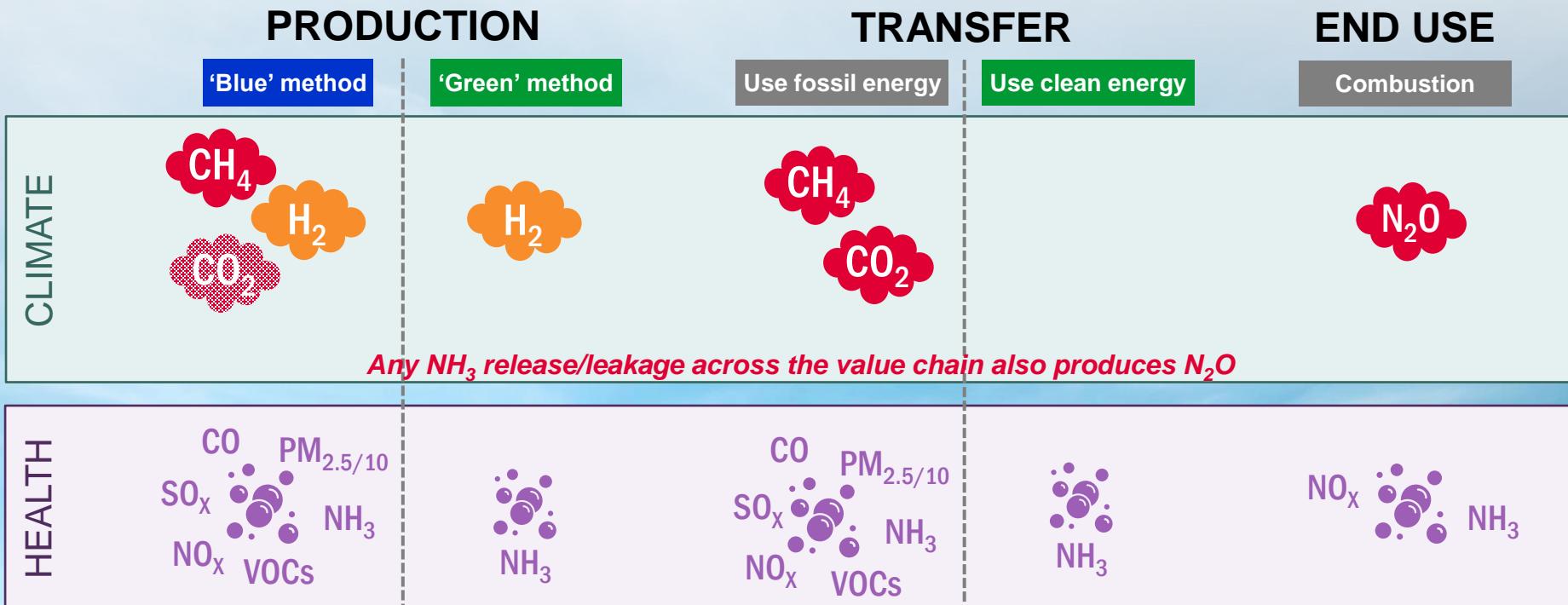


The climate and environmental impacts of ammonia: *Upstream hydrogen emissions*

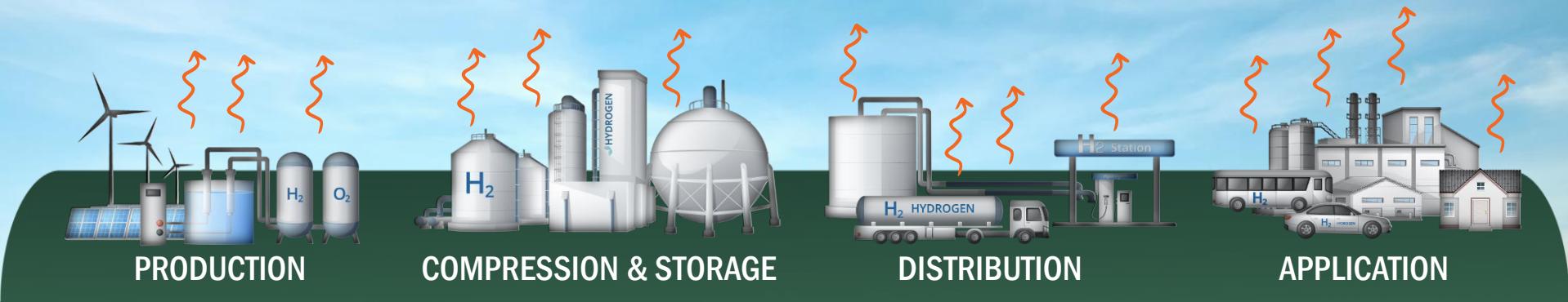
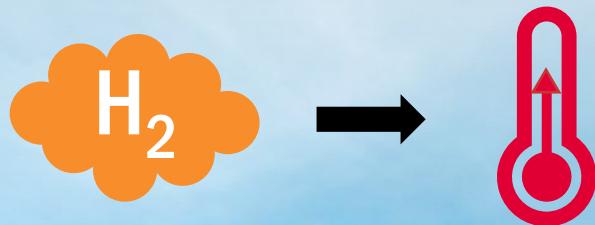
Tianyi Sun, Ph.D.
Climate Scientist
Environmental Defense Fund
tsun@edf.org

Ammonia value chain emissions



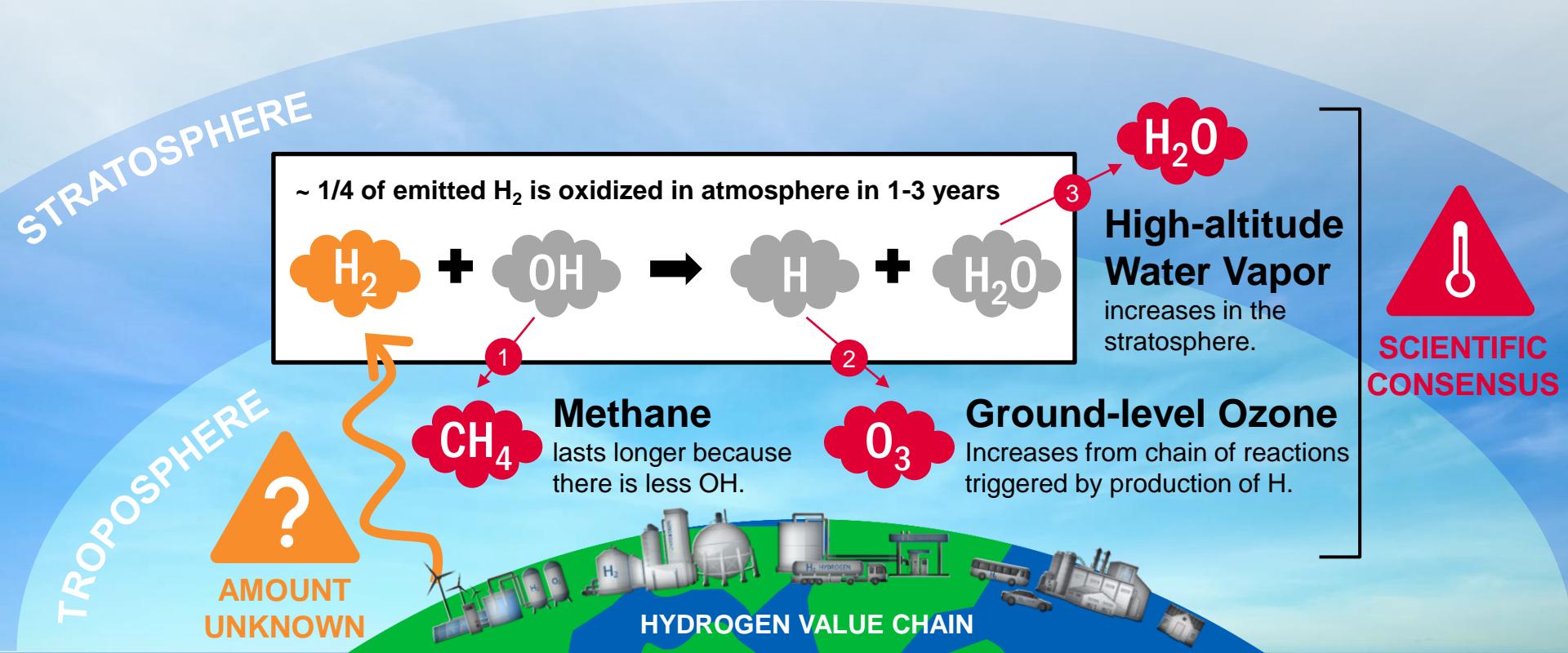
Hydrogen's warming effects

Hydrogen is a leak-prone gas that leads to potent climate warming in the near-term.



Hydrogen's warming effects

Hydrogen emissions warm the climate indirectly by increasing amounts of short-lived greenhouse gases.



State of the science

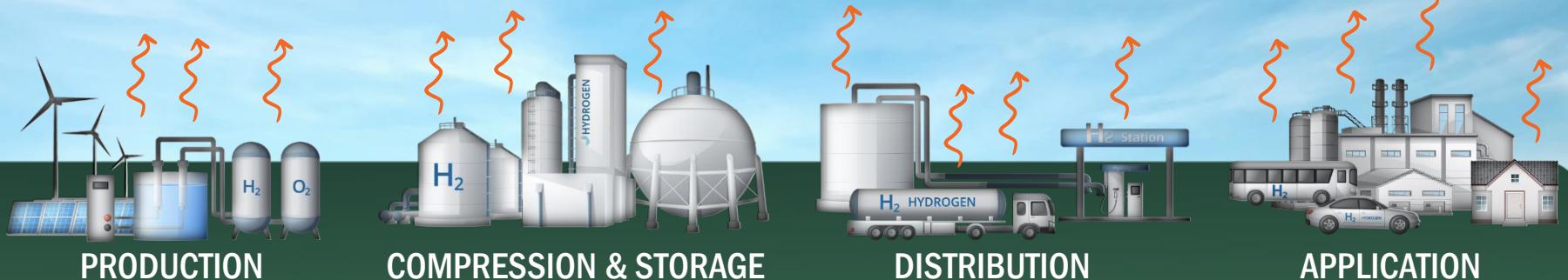
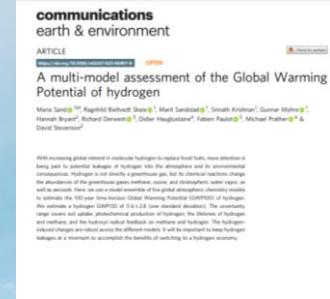
There is consensus on hydrogen's warming effects but emissions rates are unknown.



**SCIENTIFIC
CONSENSUS**

- H₂ chemistry known since the 1970s
- H₂ warming effects studied since the early 2000s
- Recent multi-model assessment concludes H₂ is **37x** more powerful at trapping heat than CO₂ **over 20-year period** and 12x over 100 years (Global Warming Potential)

Sand et al. 2023



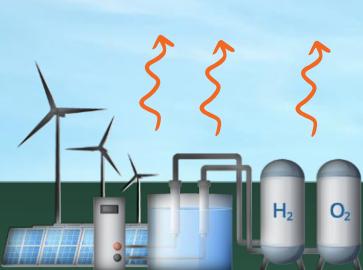
State of the science

There is consensus on hydrogen's warming effects but emissions rates are unknown.

AMOUNT UNKNOWN



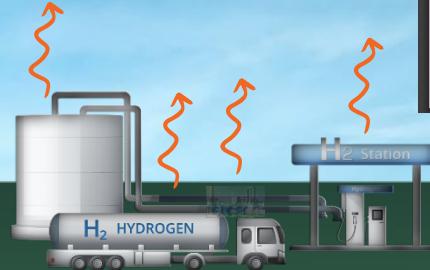
- Tiniest molecule in existence
- Intentionally & unintentionally emitted
- No empirical data from facilities
- Emissions estimates range from **<1% to 20%**
- Measurements require new sensor technologies



PRODUCTION



COMPRESSION & STORAGE

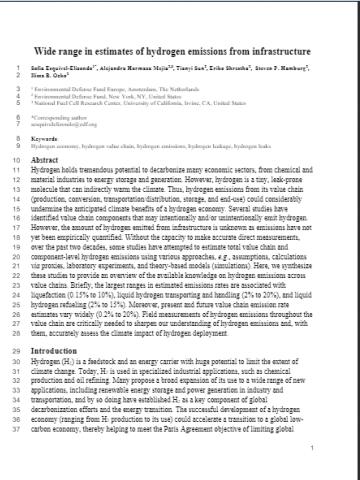


DISTRIBUTION



APPLICATION

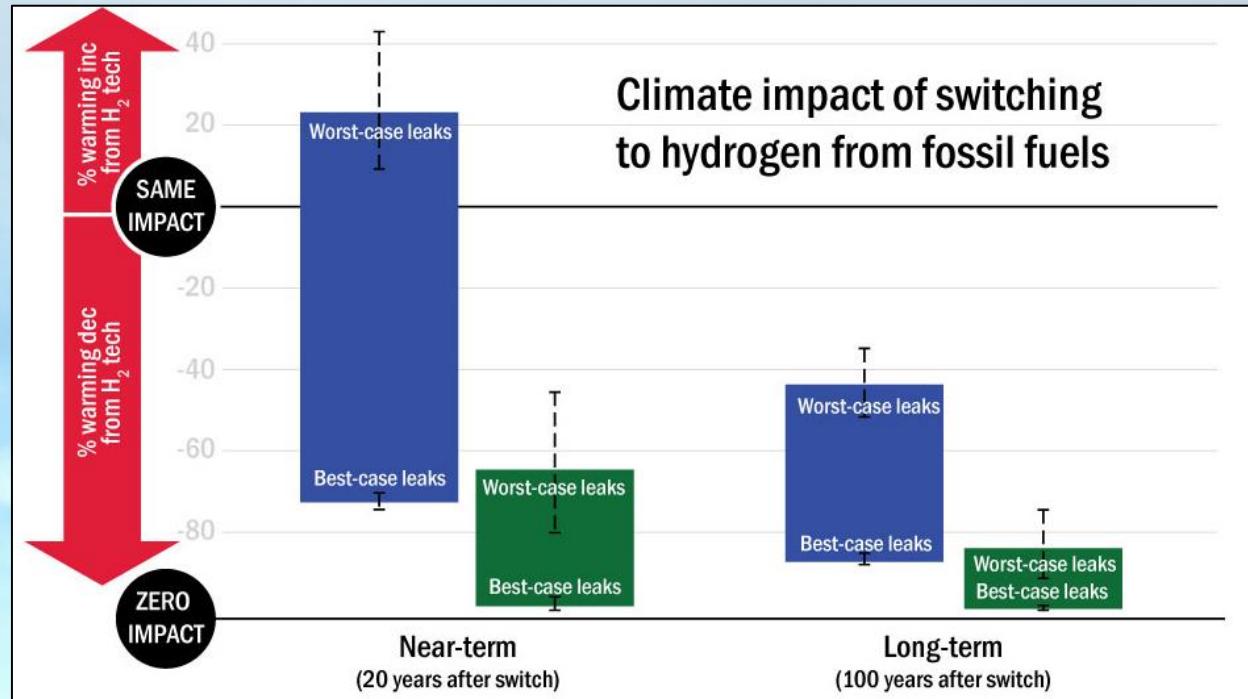
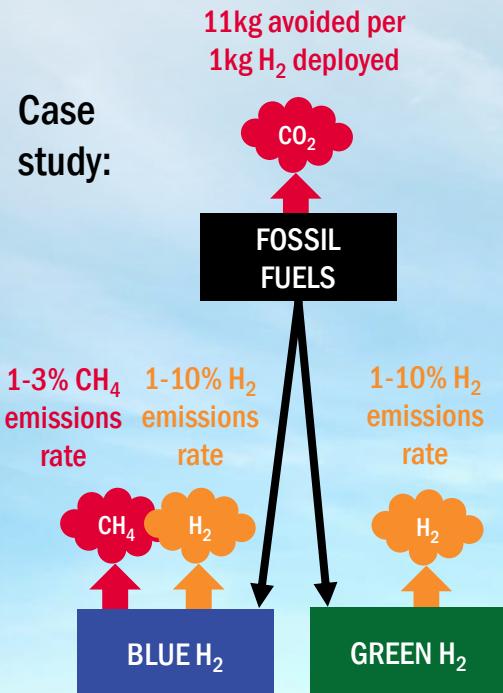
Esquivel-Elizondo et al. 2023



EDF research on the impact of hydrogen systems

Climate benefit of switching to hydrogen from fossil fuels depends on emissions and time.

Case study:



Why are there no high precision hydrogen emissions data?

We weren't looking

- Hydrogen was NOT regarded as a climate pollutant
- Its warming potential had been underestimated
- Concerns were focused on safety risks, thus larger releases

We didn't have the capacity to quantify site-level H₂ emissions



Safety sensors

Response time **a few seconds**

Sensitive at ppm or % level



Research instrument

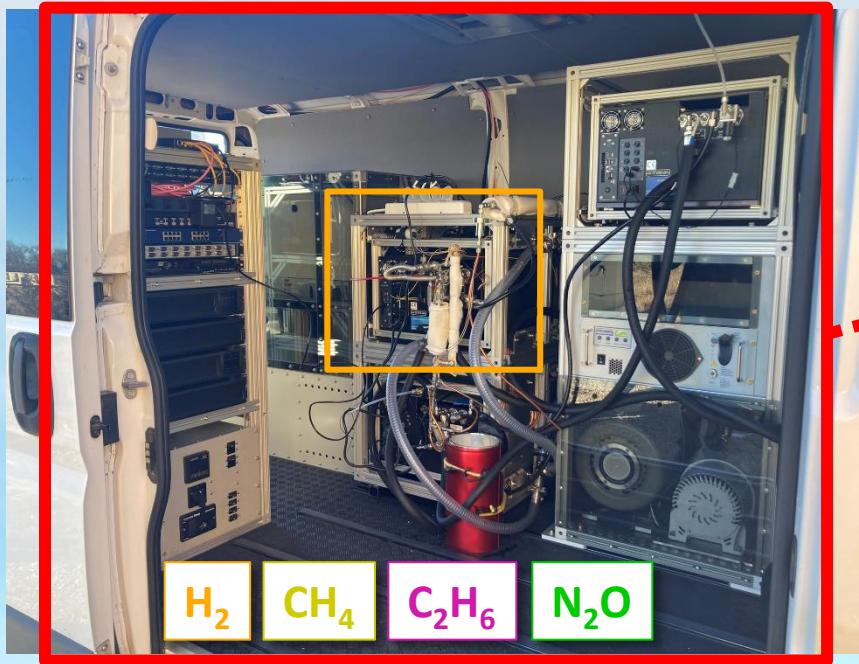
(gas chromatography)

Response time ~1 minute

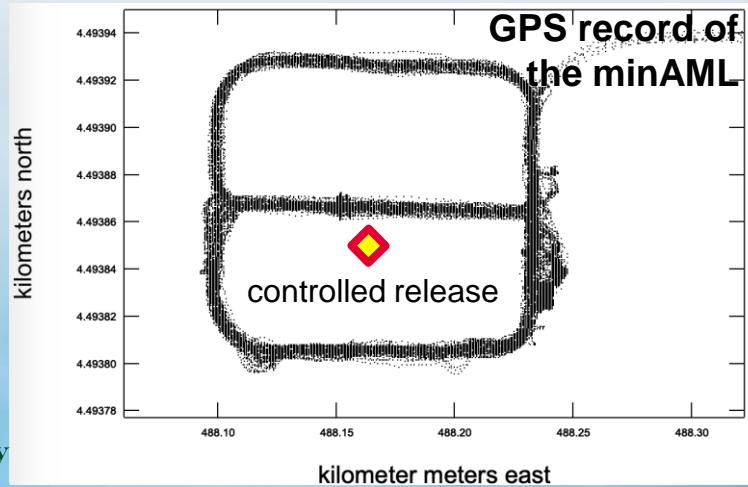
Sensitive at **ppb level**

New technology for hydrogen emissions measurement

minAML (mini-Aerodyne Mobile Lab)



First field testing at METEC, CSU

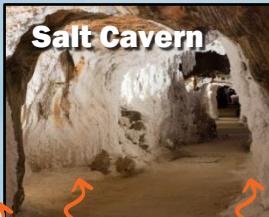


EDF hydrogen measurement campaign

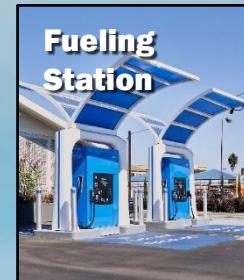
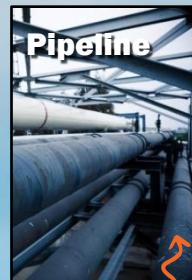
Plans underway to measure hydrogen emissions from infrastructure with new sensor technology.



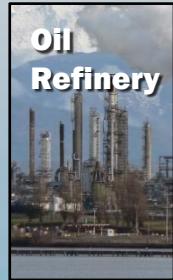
PRODUCTION



COMPRESSION & STORAGE

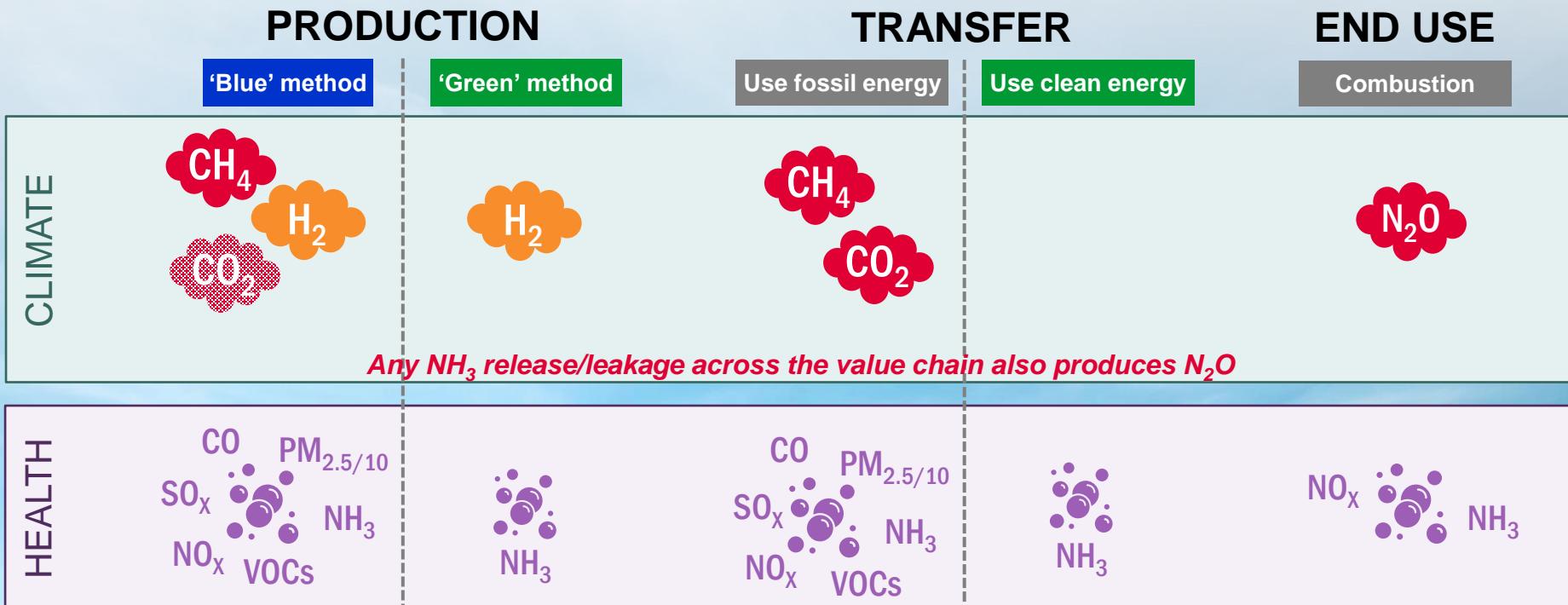


DISTRIBUTION



APPLICATION

Ammonia value chain emissions



Thank you!