

Maximizing the climate benefits of hydrogen:

Hydrogen emissions

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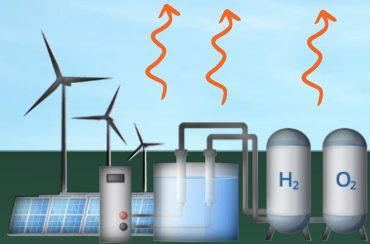
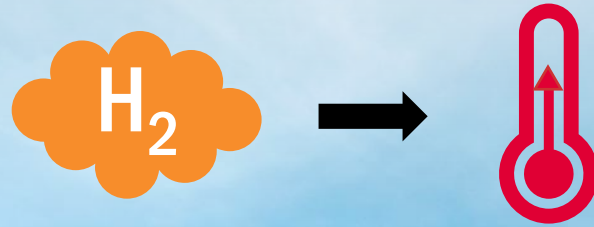
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Hydrogen's climate risk

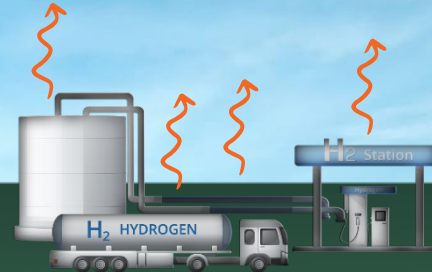
Hydrogen is a leak-prone gas that leads to potent climate warming in the near-term.



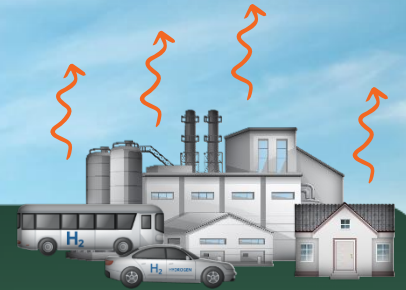
PRODUCTION



COMPRESSION & STORAGE



DISTRIBUTION

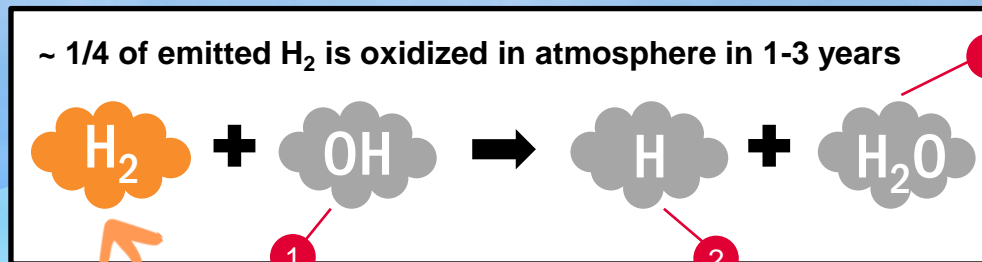


APPLICATION

Hydrogen's warming effects

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

STRATOSPHERE



High-altitude Water Vapor

increases in the stratosphere.

TROPOSPHERE



Methane

lasts longer because there is less OH.



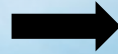
Ground-level Ozone

Increases from chain of reactions triggered by production of H.

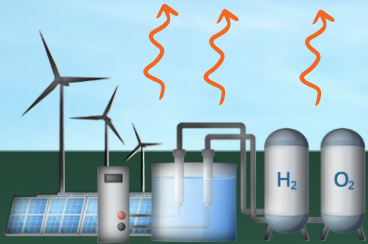
State of the science

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

AMOUNT
UNKNOWN



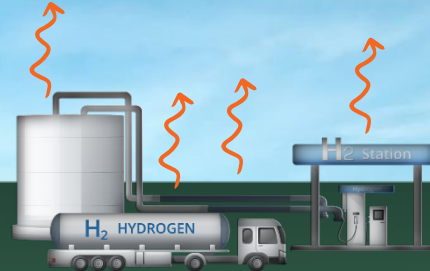
EMERGING
CONSENSUS



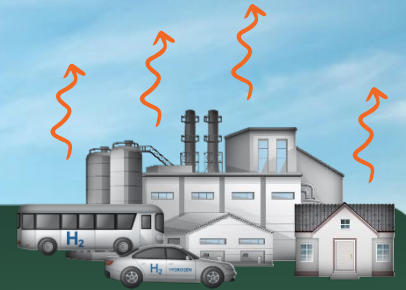
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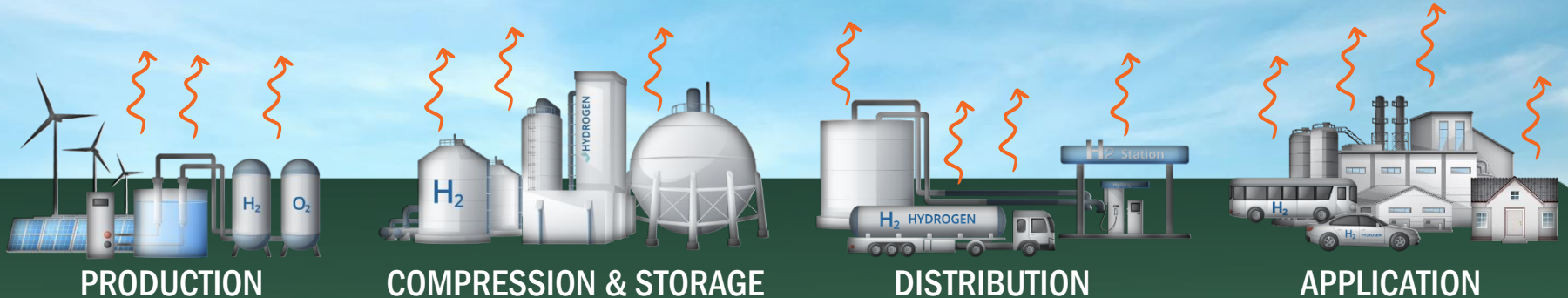
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EMERGING CONSENSUS

- H₂ chemistry known since the 1970s
- H₂ warming effects studied since the early 2000s
- Latest science suggests H₂ is **40x** more powerful at trapping heat than CO₂ **over 20-year period** and 12x over 100 years (Global Warming Potential)



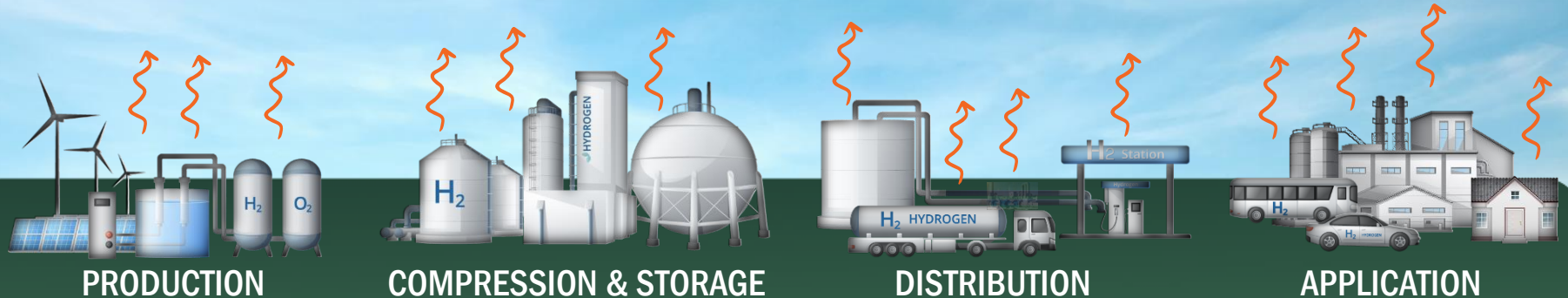
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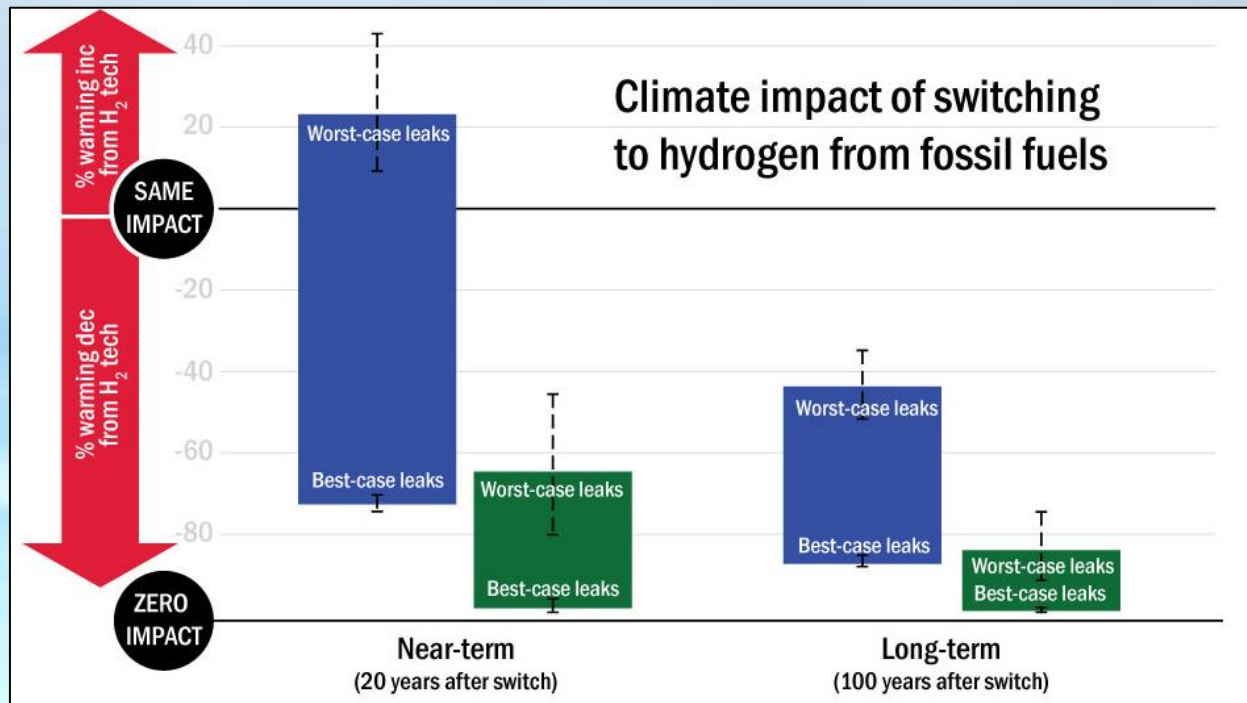
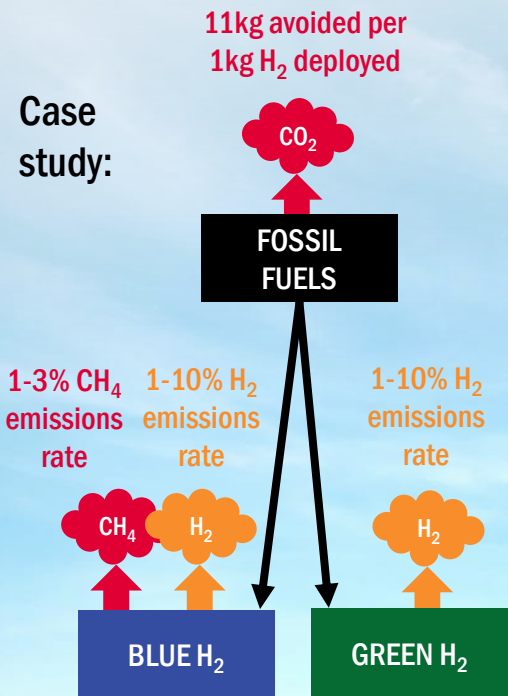


- Tiniest molecule in existence
- Intentionally & unintentionally emitted
- No empirical data from facilities
- Emissions estimates range from **<1%** to **20%**
- Measurements require new sensor technologies



Seriousness of issue

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



Actions to minimize hydrogen emissions

Several actions can be taken immediately to minimize hydrogen emissions and maximize climate benefits.



Sensors Development

R&D for sensor equipment capable of detecting small leaks



Measure Emissions

Test sensor tech and support measurement campaigns



Minimize Emissions

Identify leakage mitigation measures, venting/purging alternatives, and best practices



Emissions Programs

Incorporate plans for Monitoring, Reporting, Verification and Leak Detection and Repair programs



Incorporate in LCAs

Incorporate H₂ emissions and warming effects in Life Cycle Assessment calculations

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