CLEAN AIR TASK FORCE

Hydrogen Blending - Not a serious decarbonization pathway

An assessment of blending low-carbon hydrogen in gas grids as an environmental solution

Summary

Hydrogen blending generally refers to the injection of low-carbon hydrogen into the natural gas grid to partially decarbonize natural gas users. This method may seem appealing since it can capitalize on existing natural gas transmission and distribution infrastructure. However, hydrogen blending is neither an economical nor an effective decarbonization strategy.

Key Messages

The capability of existing natural gas infrastructure to withstand hydrogen blends at low concentrations (eg. 1% - 10% volume) is dependent on a range of factors and needs to be evaluated on a case-by-case basis. Significant upgrades to the network are required at higher blends (eg. > 20% volume).

Estimated emissions reductions from hydrogen blending are insignificant at 20% volume and only meaningful at high hydrogen blends.

The carbon abatement costs associated with hydrogen blending may be prohibitive and exceed $300/tonne CO_2.

Blending hydrogen into the grid is an **inefficient use of a valuable resource** better suited to directly decarbonize sectors that lack decarbonization alternatives, such as the industrial sector.

Hydrogen blending at low blends does not offer a clear or credible pathway for decarbonizing existing natural gas users which are better served by other technologies.

Estimated emissions savings with hydrogen blending

Estimated emissions reductions from hydrogen blending are insignificant at 20% volume and only meaningful at high hydrogen blends (above 80% volume).

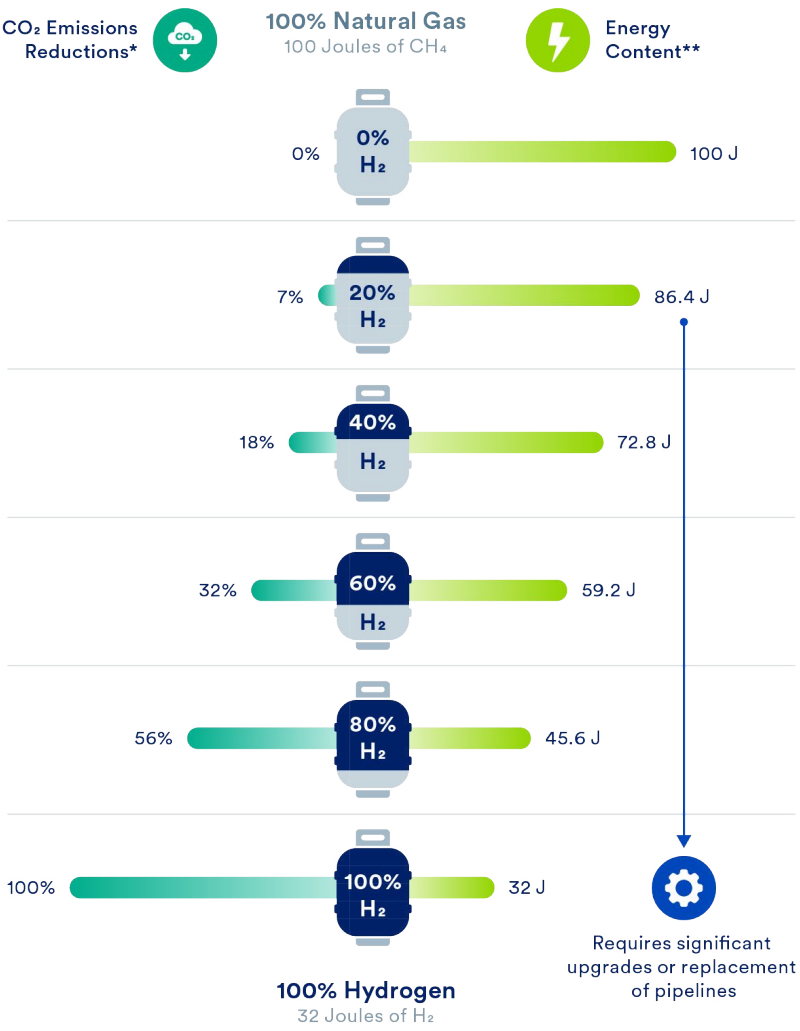
The introduction of hydrogen into the natural gas grid dilutes the energy content on a volumetric basis, as hydrogen has roughly 1/3 of the volumetric energy density as that of natural gas.

Higher volumetric flow rates of hydrogen blends are required to compensate for the drop in volumetric energy density. Even so, existing natural gas grids will experience a reduction in transmissible energy capacity.

It takes approximately **three times the compression energy** to move an equivalent amount of energy in the form of hydrogen compared to that in the form of natural gas.

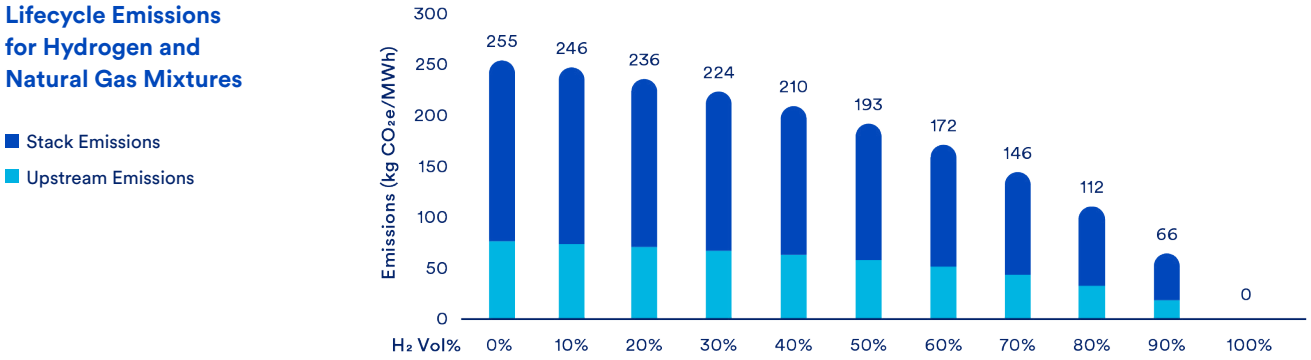
This implies **higher operating and energy costs** for a hydrogen gas grid vs. natural gas grid only based on compression energy required.[1]

* Emissions reductions at various hydrogen blends vary depending on whether upstream natural gas emissions are included or not (life cycle emissions CO_2e). However emissions reduction percentages remain the same.



[1] Recent analysis from Argonne National Laboratory demonstrated that blending hydrogen at 30% by volume only yielded a 6% reduction in lifecycle emissions due to increased leakage from transmission lines owing to increased pipeline flow rates and pressure required to deliver the same amount of energy as that with no hydrogen introduced.

Lifecycle Emissions for Hydrogen and Natural Gas Mixtures



* Natural gas supply chain carbon intensity is 21.5 kg CO_2e/GJ-HHV. Assumes 1% upstream methane emissions and 0.4 kg CO_2/kg natural gas total exploration and production CO_2 emissions.

** Natural gas upstream emissions refer to methane emissions arising from flaring and leakage in the production and transmission infrastructure in addition to CO_2 emissions associated with the production, processing, transmission, and storage of natural gas.

Carbon abatement costs of hydrogen blending

The carbon abatement costs associated with hydrogen blending may be prohibitive and exceed $300/tonne CO_2.

The carbon abatement costs of hydrogen blending[2] exceeds the current or any potential future carbon pricing. Carbon abatement costs for alternate decarbonization pathways in the power and residential sector, which are currently served by the natural gas grid, are significantly lower, rendering hydrogen blending uncompetitive.

Minimum achievable **'green' hydrogen** production cost stands at **$3/kg**.

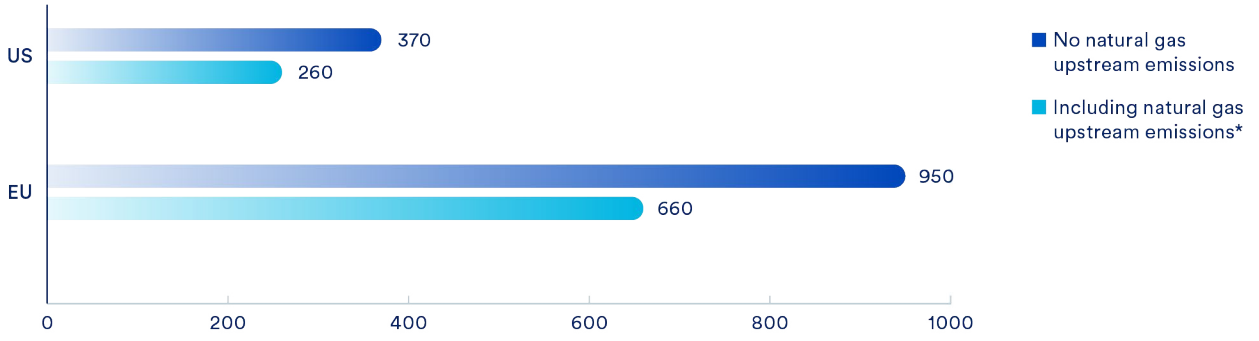
Wholesale production prices in Europe today are in the **$6-$8/kg** range.



Location	$/kg Hydrogen	$/MMBTU Natural Gas	Relative Energy Cost of Hydrogen to Natural Gas
USA	$3	$3	~7.5
EU	$8	$10	~6

[2] The carbon abatement cost for a given hydrogen and natural gas price combination is the same irrespective of the blending ratio.

Carbon Abatement Cost USD / tonne CO_2



* Natural gas supply chain carbon intensity is 21.5 kg CO_2e/GJ-HHV. Assumes 1% upstream methane emissions and 0.4 kg CO_2/kg natural gas total exploration and production CO_2 emissions. When natural gas upstream emissions are included, the abatement cost is calculated based on CO_2e.

** Assumes electrolytic hydrogen with zero emissions. Accounting for Infrastructure and supply chain emissions from clean sources of electricity such as hydro, geothermal, nuclear, solar, and wind increases the lifecycle carbon abatement costs by approximately 10%.

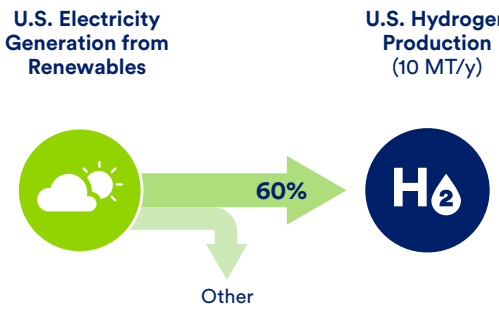
Inefficient use of a valuable resource

Despite a plethora of recent project announcements, **low-carbon hydrogen is currently in short supply and will remain so for the foreseeable future.**

The availability of cheap (<$20/MWh), clean, and reliable electricity is already a bottleneck to decarbonize the existing power system. Low-carbon, electrolytic hydrogen whose production increases demand on the electrical grid must be directed to applications with the greatest carbon abatement potential.

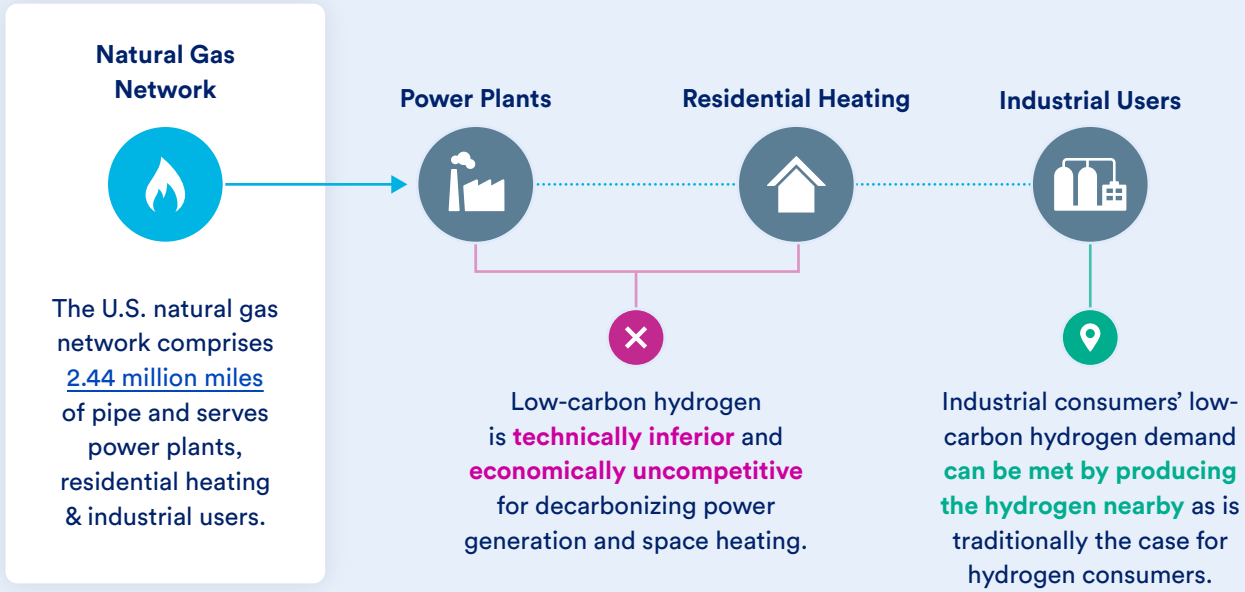
Replacing current hydrogen production dedicated to refining, ammonia, and methanol production (where no feasible alternatives exist) with low-carbon hydrogen should be a top priority and is already a herculean task.

Furthermore, any remaining supply of low-carbon hydrogen should be directed towards sectors that have limited or no decarbonization alternatives, particularly other industrial sectors like iron production or heavy transportation sectors.



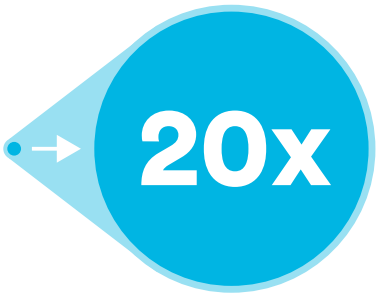
Supplying all current U.S. **dedicated hydrogen production (10 MT/y)** using water electrolysis **would consume more than half (60%) of all current U.S. electricity generation from renewables.**

Hydrogen blending: unclear pathway to full decarbonization



Even if hydrogen were competitive for today's three major users of natural gas, higher hydrogen blends could require essentially rebuilding the entire natural gas transmission and distribution network which took several decades to build and would potentially cost tens if not hundreds of billions of dollars.

The endgame to hydrogen blending in the natural gas grid is unclear and unlikely to yield meaningful environmental benefits.



Replacing the U.S.'s entire natural gas consumption would consume the equivalent of **20 times the current U.S. hydrogen production level.***

* The estimate above is for illustrative purposes and excludes industry's use of natural gas as a feedstock.

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