Life Cycle Assessment of a coal-based hydrogen supply chain for energy and agriculture in the Appalachian region

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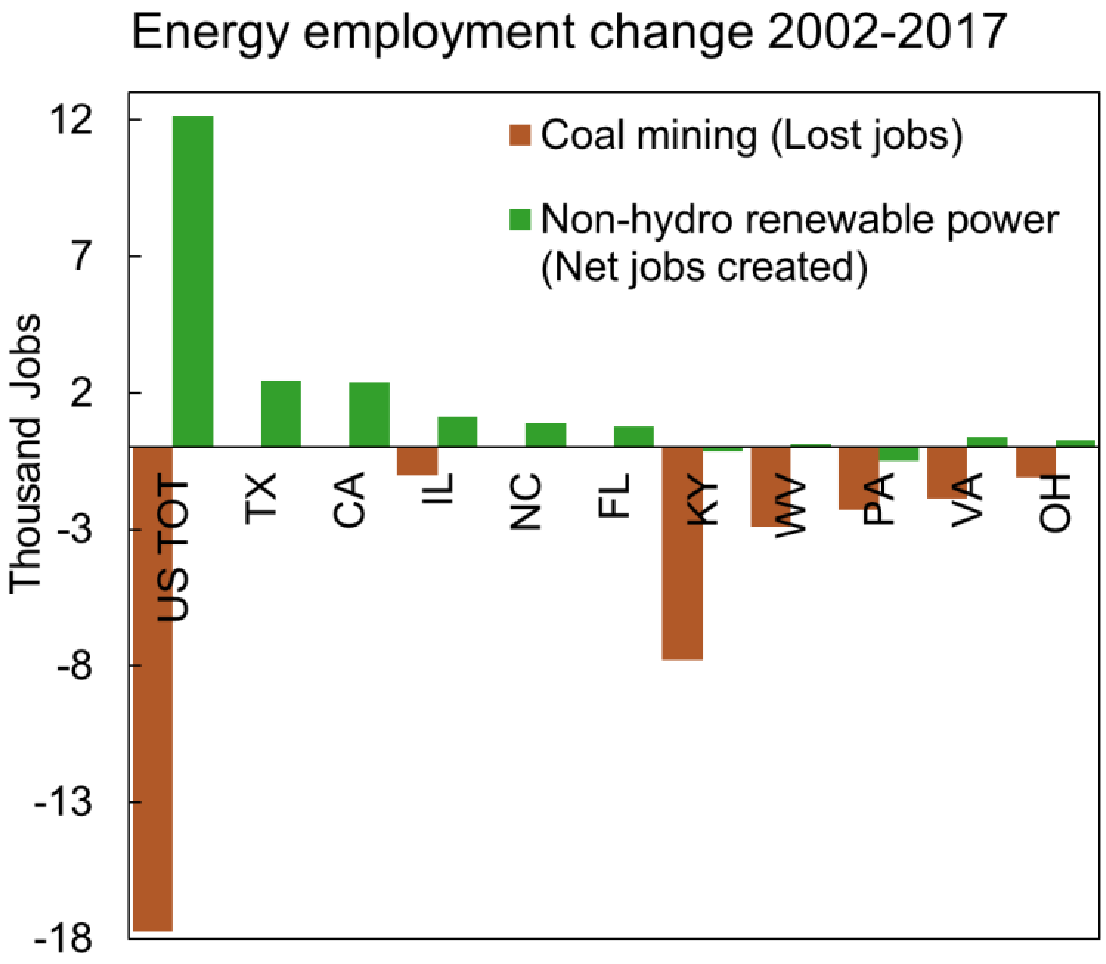
Uneven distribution of decarbonization cost and benefits

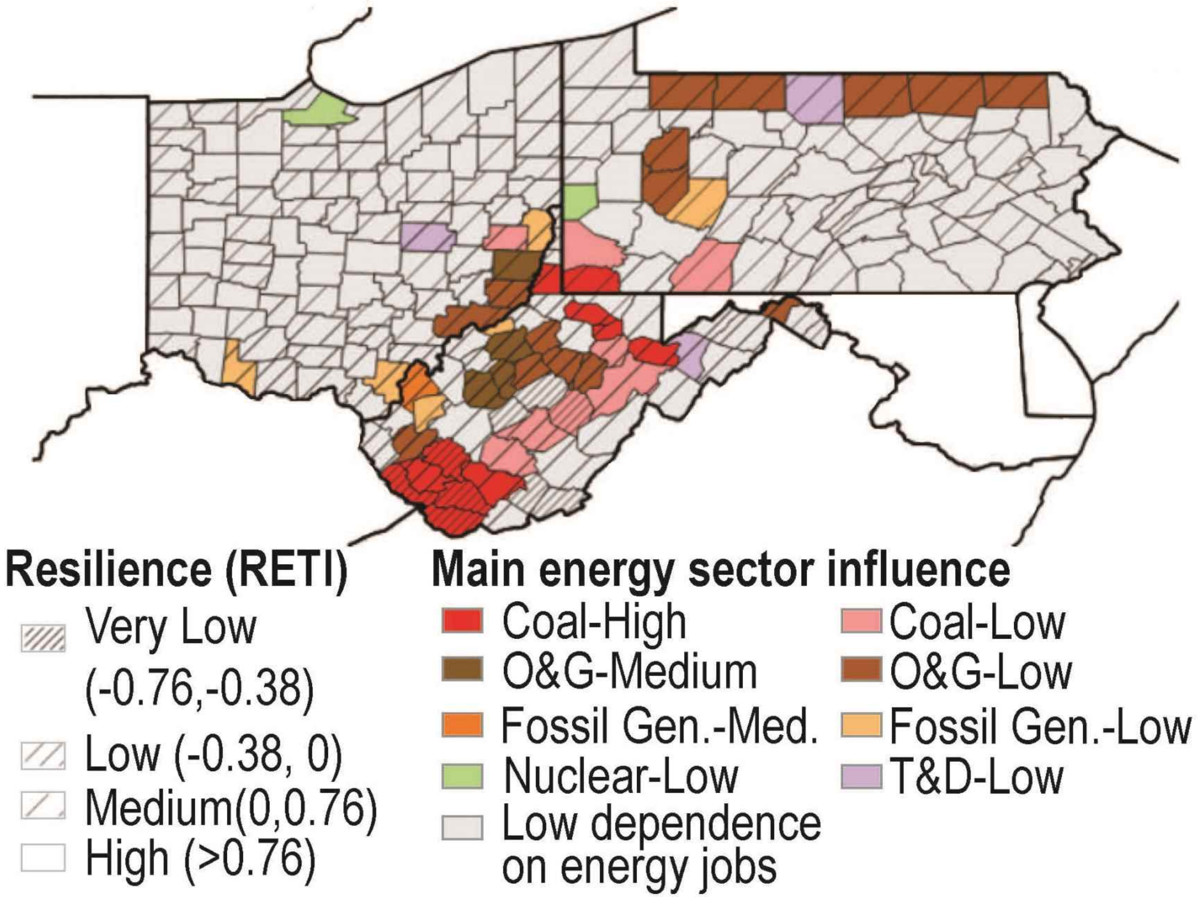
https://www.theage.com.au/national/victoria/



[1] Prepared from IMPLAN Employment data. *IMPLAN Industry Data 2018*. https://support.implan.com/hc/en-us (2018).

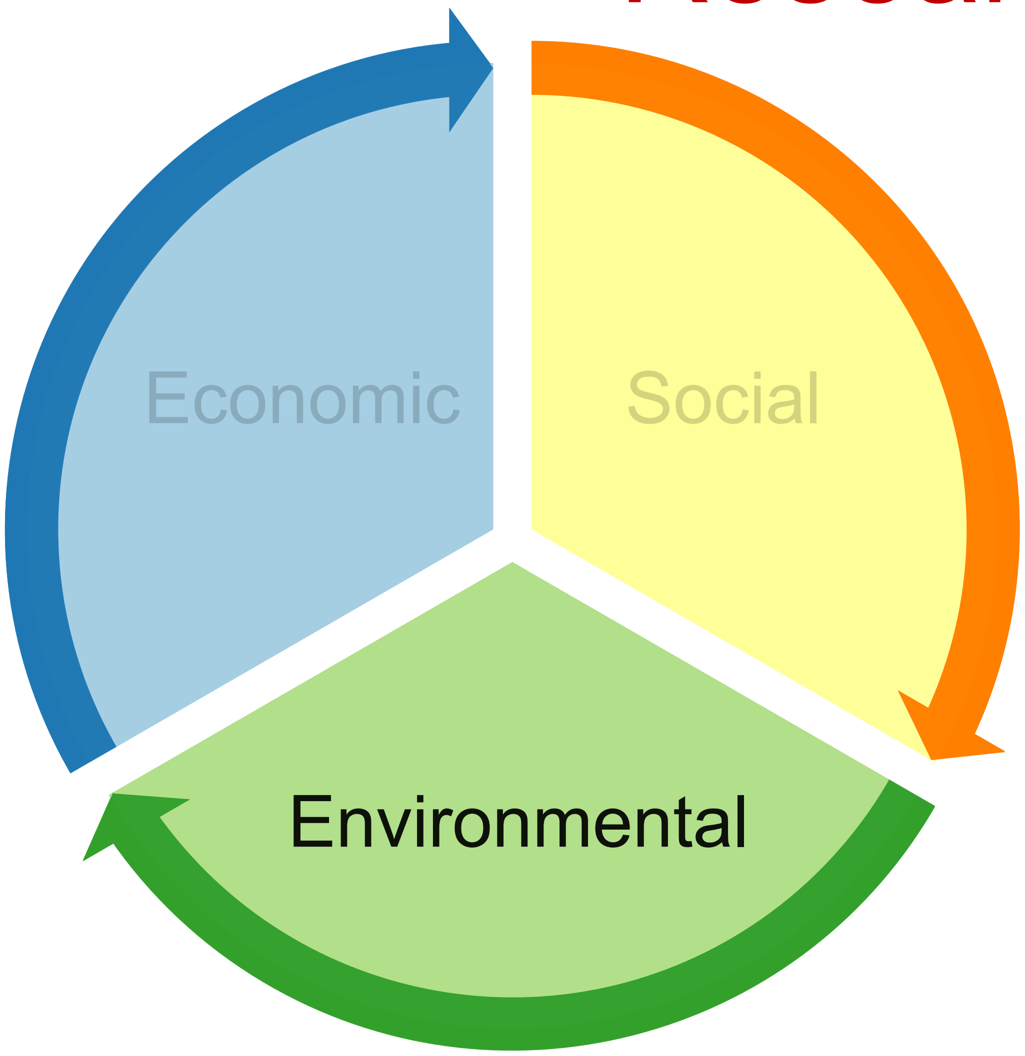
H_2 from coal with potential to strengthen vulnerable communities

- Coal-dependent communities are at double risk
- H_2 diversification builds temporary transition bridges
- Decarbonizes thermal fuel industry



[1]Hincapie-Ossa, D., Frey, N., & Gingerich, D.; Assessing County-Level Vulnerability to the Energy Transition in the United States Using Machine Learning. Under review in *Energy Research and Social Sciences Journal*

Research question

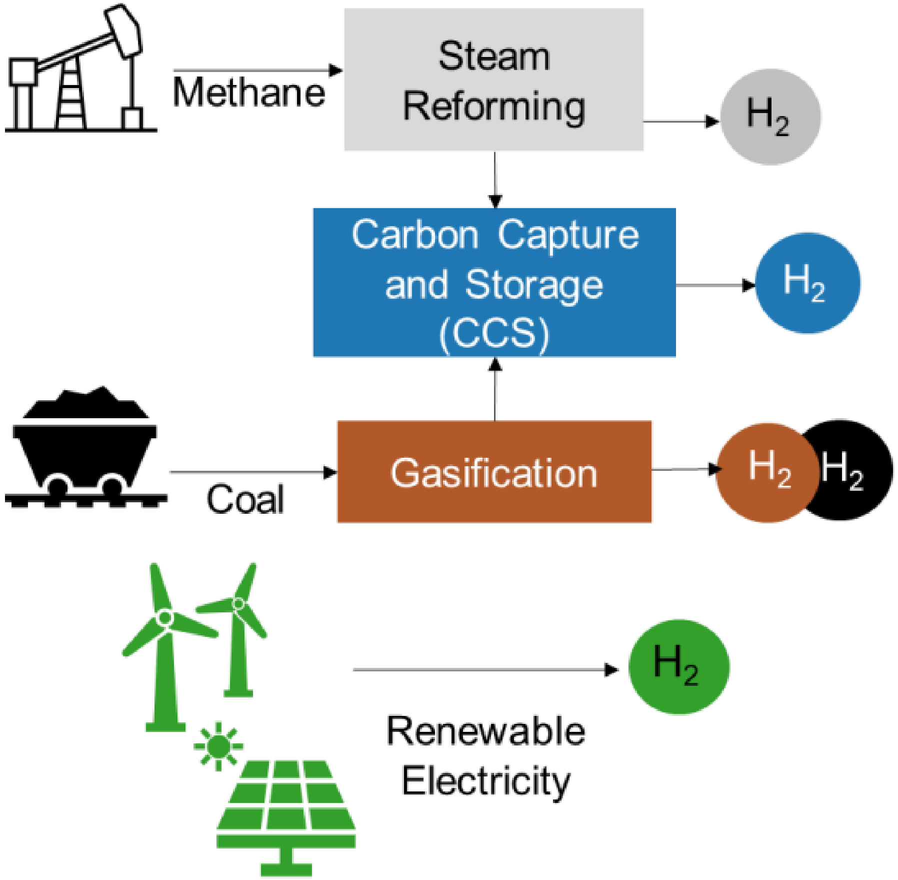


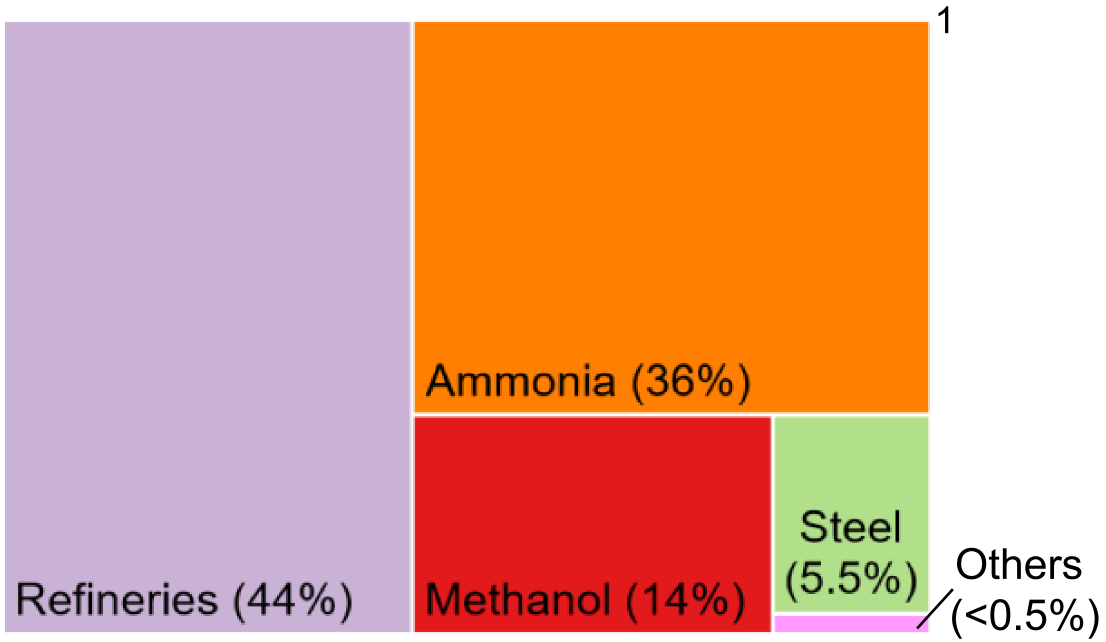
How does the lifecycle environmental performance of H_2 from Appalachian coal compare to the current alternatives?

Does the coupled production of H_2 (fuel) and NH_3 (fertilizer precursor) enable environmental benefits?

H_2 flexible supply chain can be leveraged to improve performance

- H_2: no CO_2 when combusted
- High energy density (per unit of mass)





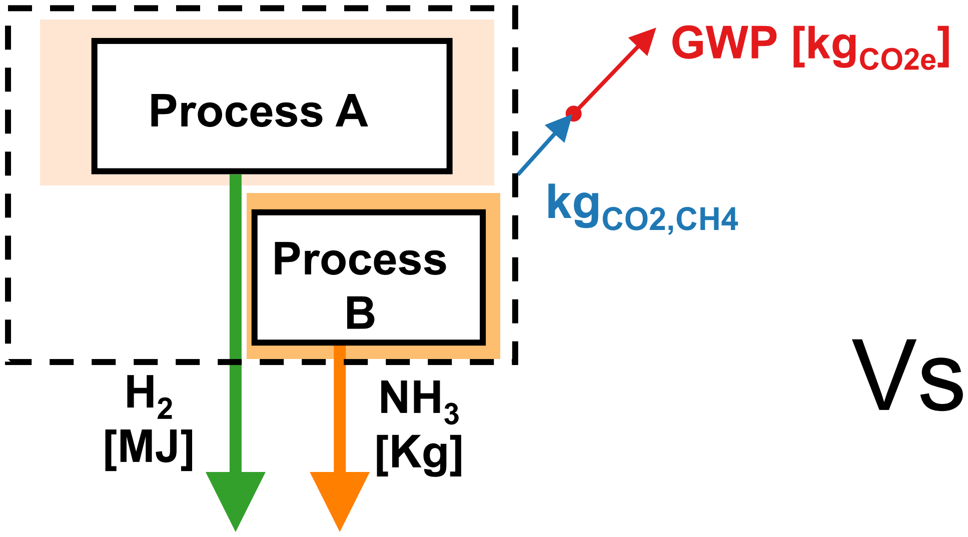
Standalone Fuel?

[1] Adapted from IEA (2022). Ammonia Technology Roadmap

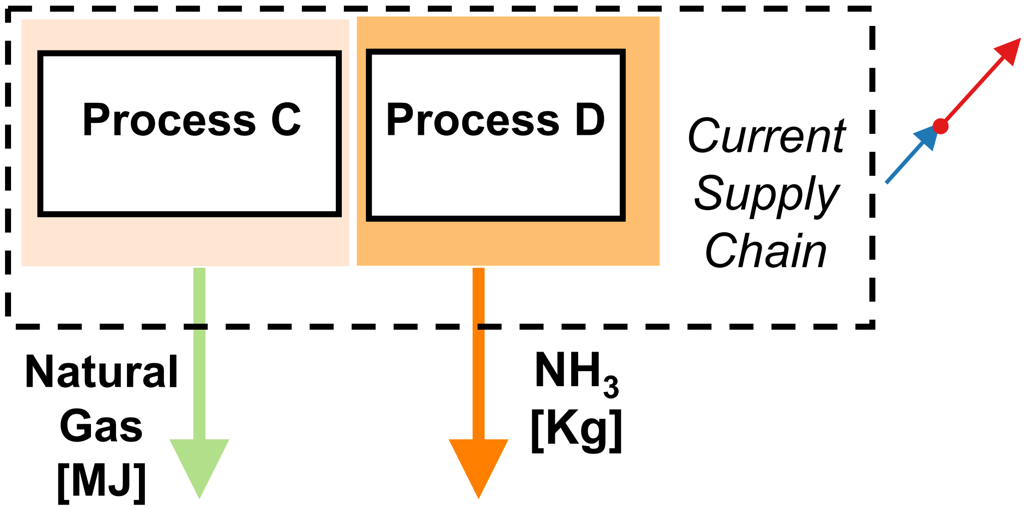
Life Cycle Assessment: Standardized impact study enabling comparisons

- Based on simulation of material flows with system view
- Comprehensive impacts from all the industrial system

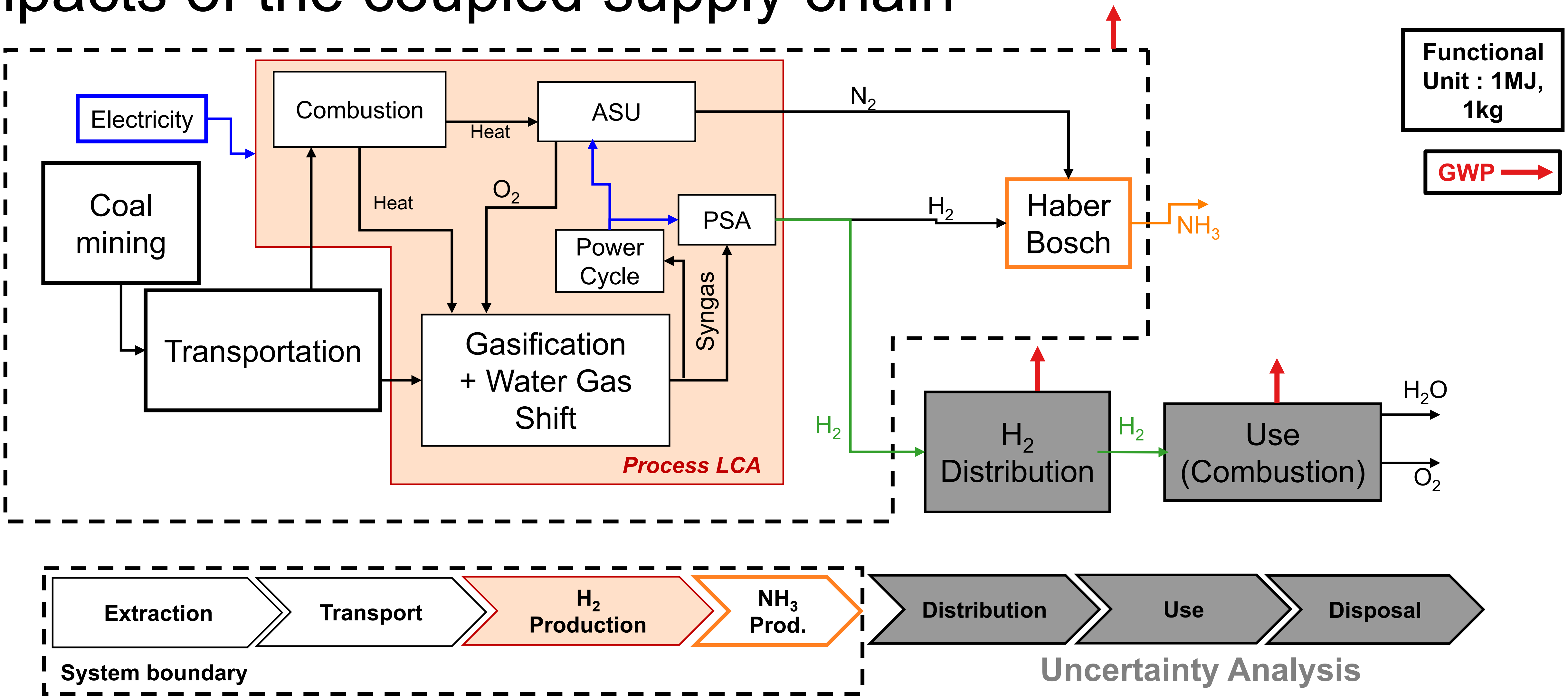
FUNC. UNIT
Impacts per
MJ and kg



Vs



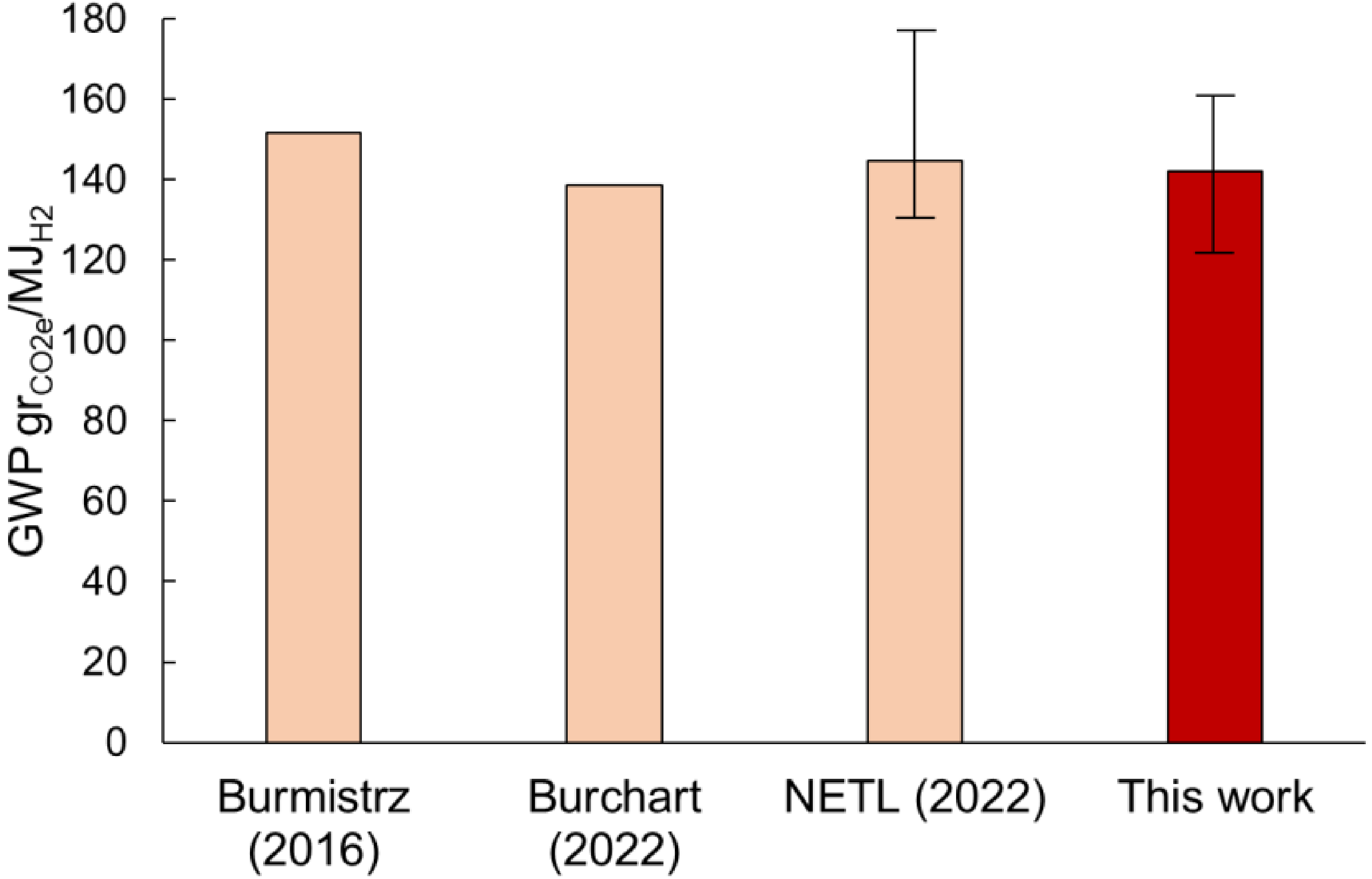
A ‘Cradle-to-gate’ analysis captures the differential impacts of the coupled supply chain



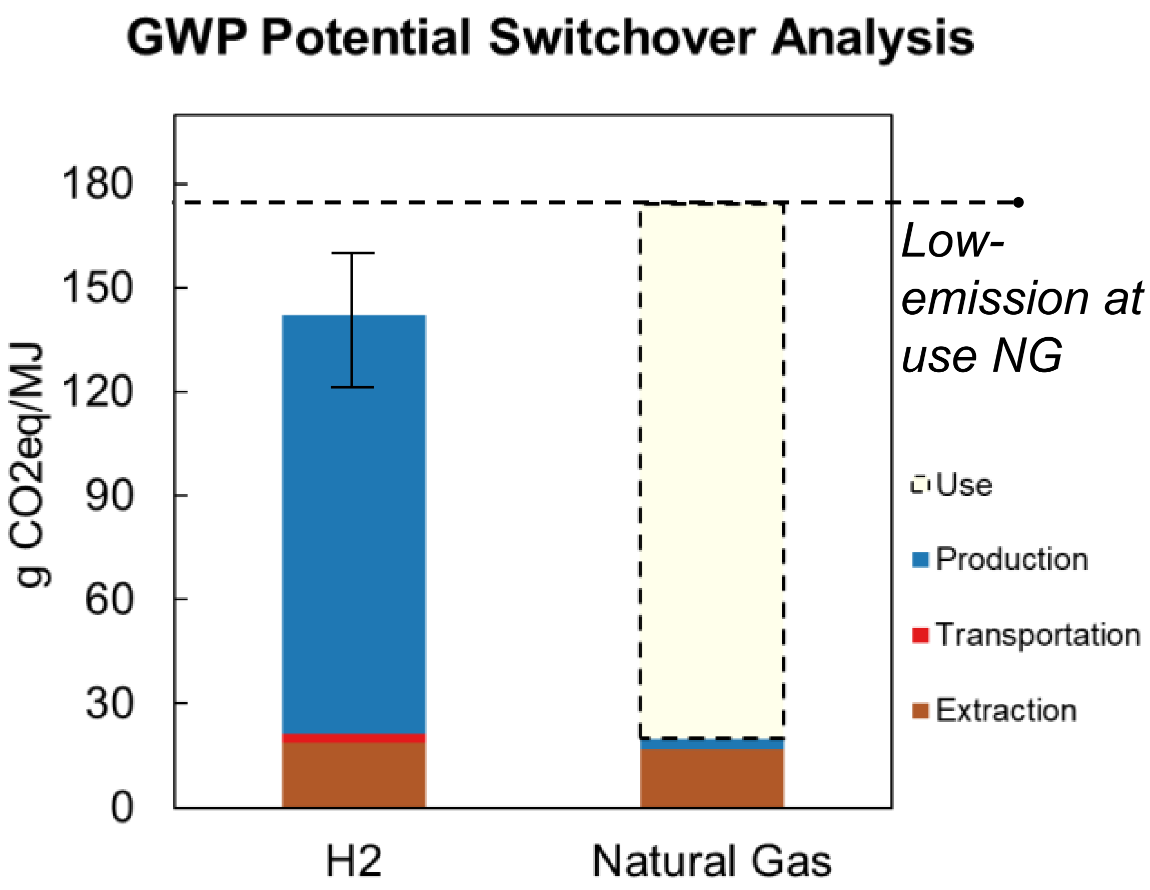
H_2 production results consistent with harmonized LCA literature

Consistent assumptions:

- Gasification in Ohio from Appalachian coal
- Mature technology in efficient configuration:
  - Dry-fed
  - Entrained bed
  - H_2 is main product



After usage, H_2 is likely to outperform NG in GWP



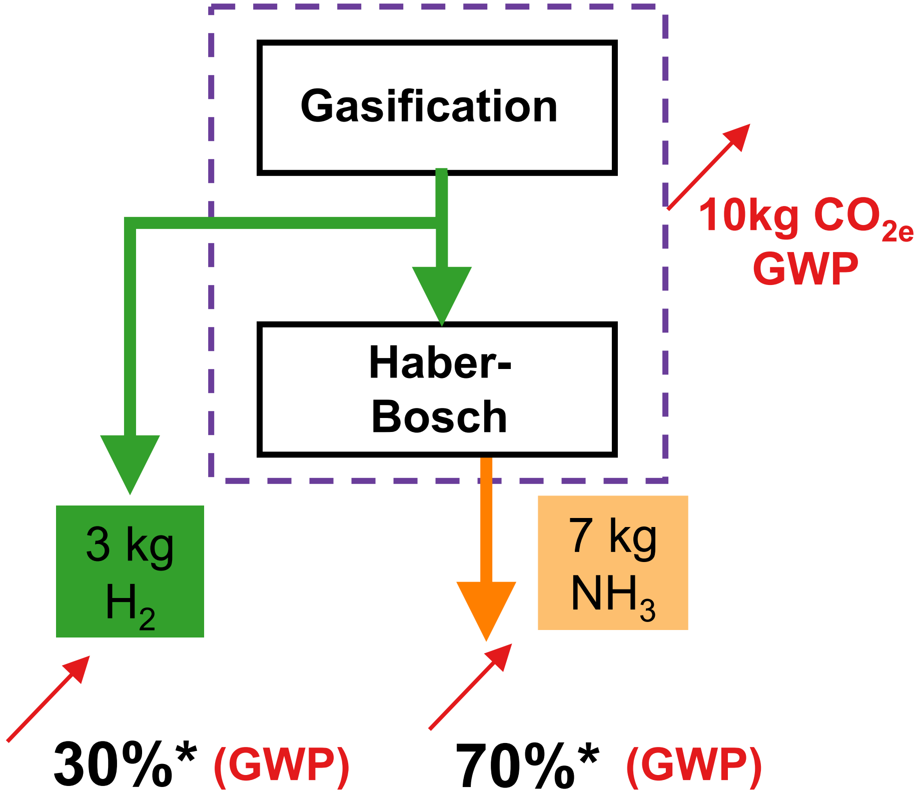
- The cradle-to-gate analysis favors Natural Gas (NG)

- A conservative estimate: NG emits 152_{CO2e}/MJ at combustion
- NG GWP has 6.7% more impact than 'high impact scenario' for H_2

Assigning impacts from shared process in co-production

For each 10 kg of CO_2 , how much is considered emitted by the H_2 manufacturing and how much by NH_3 ?

We used: "Mass Allocation"
Proportional to the mass of the products



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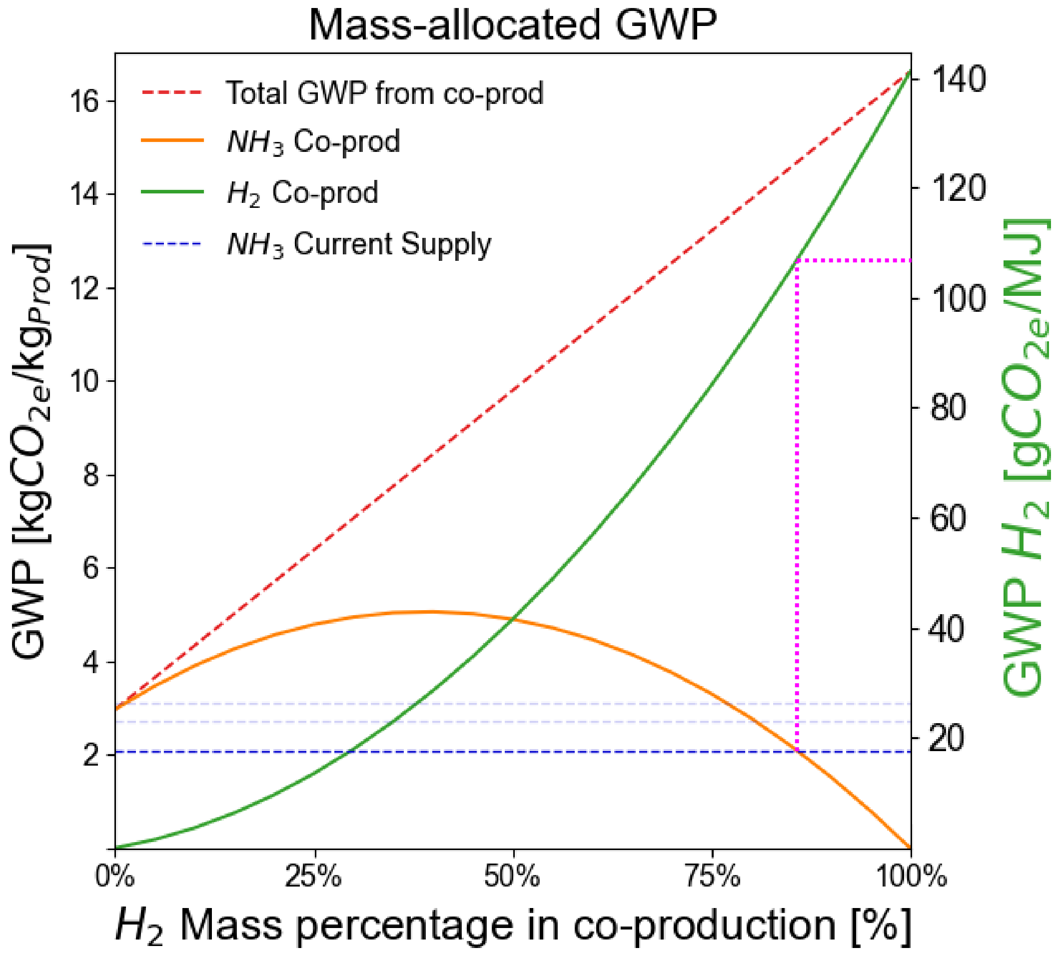
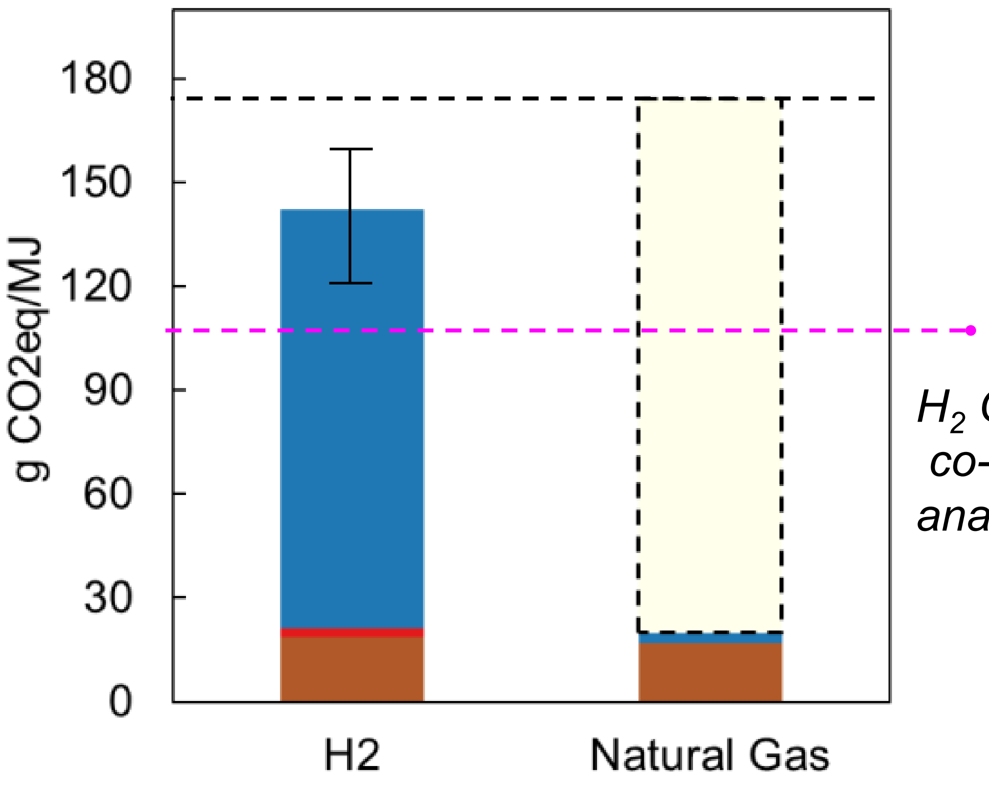
Local co-production that matches the current NH_3 supply makes H_2 comparatively even better





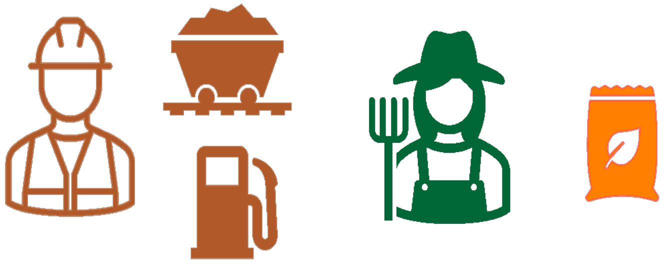
H_2 GWP after co-production analysis

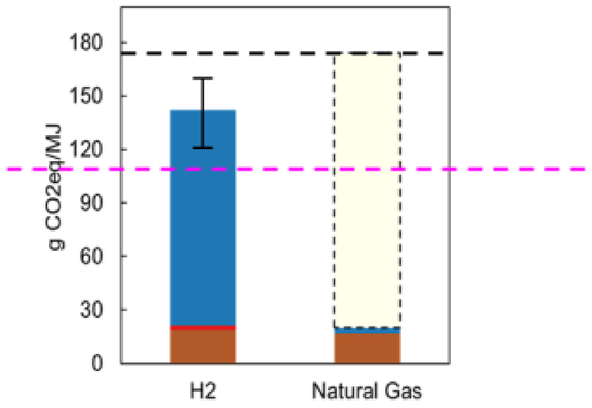
Conclusions

Potential benefits beyond job creation and resilience contribution:

- Coal-based H_2 has potential to be more environmentally sustainable than current supply of natural gas

- A coupled-sector LCA reveals hidden environmental benefits from co-producing H_2-NH_3





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