

Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our [Editorial Policies](#) and the [Editorial Policy Checklist](#).

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed
☒	☐ The exact sample size (<i>n</i>) for each experimental group/condition, given as a discrete number and unit of measurement
☒	☐ A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☒	☐ The statistical test(s) used AND whether they are one- or two-sided <i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i>
☒	☐ A description of all covariates tested
☒	☐ A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☒	☐ A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☒	☐ For null hypothesis testing, the test statistic (e.g. <i>F</i> , <i>t</i> , <i>r</i>) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> value noted <i>Give P values as exact values whenever suitable.</i>
☒	☐ For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐ For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐ Estimates of effect sizes (e.g. Cohen's <i>d</i> , Pearson's <i>r</i>), indicating how they were calculated

Our web collection on [statistics for biologists](#) contains articles on many of the points above.

Software and code

Policy information about [availability of computer code](#)

Data collection	The data used to conduct this analysis were obtained from the Ecoinvent database v.3.10 released in 2023 in addition to available hydrogen leakage rates obtained from a study conducted by Esquivel-Elizondo S., et al and GWP100, and GWP20 of hydrogen obtained from a study conducted by Hauglustaine., et al
Data analysis	We use a life cycle assessment (LCA) model constructed through the Open LCA software v.2.10 and the IPCC 2021 impact assessment method to estimate greenhouse gas emissions intensity of various hydrogen production pathways

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio [guidelines for submitting code & software](#) for further information.

Data

Policy information about [availability of data](#)

All manuscripts must include a [data availability statement](#). This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our [policy](#)

The data supporting the findings of this project are derived from two primary sources: the Ecoinvent database and previously published literature referenced within

the text.

- Ecoinvent Database: Data sourced from the Ecoinvent database are subject to the terms and conditions of the Ecoinvent license agreement. Access to this data can be obtained through a subscription to the Ecoinvent database, available at <https://www.ecoinvent.org>. Due to licensing restrictions, these data cannot be shared directly by the authors.
- Published Literature: Data extracted from previously published literature are available from the original publications, as referenced in the text. Interested parties can access these publications through the respective journals or publishers, subject to the access policies of those sources.
- The key inputs and outputs of the models and included in the methods section and the data used to construct figures was deposited in the Texas data repository

Research involving human participants, their data, or biological material

Policy information about studies with [human participants or human data](#). See also policy information about [sex, gender \(identity/presentation\), and sexual orientation](#) and [race, ethnicity and racism](#).

Reporting on sex and gender	N/A
Reporting on race, ethnicity, or other socially relevant groupings	N/A
Population characteristics	N/A
Recruitment	N/A
Ethics oversight	N/A

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☐ Behavioural & social sciences ☒ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	The goal of this assessment is to quantify the impact of hydrogen's indirect climate effects and leakage rates on the life cycle emissions of different hydrogen production methods and end uses. We use a life cycle assessment (LCA) model constructed through the Open LCA software v.2.10 and the IPCC 2021 impact assessment method to estimate greenhouse gas emissions intensity of various hydrogen production pathways. The production methods taken into consideration in this analysis are unabated SMR (SMR without CCS), SMR coupled with 96% CCS (SMR+CCS), electrolysis using a grid mix supply of electricity, electrolysis using solar (equivalent kWh not hourly matched), and electrolysis using wind energy (equivalent kWh not hourly matched). The steel and heavy-duty transport pathways selected are based in Texas to mimic future scenarios as one of the DOE hydrogen hubs, Gulf Coast Hydrogen Hub (HyVelocity), is expected to be constructed in Houston.
Research sample	N/A
Sampling strategy	N/A.
Data collection	The data used in this study was primarily obtained from ecoinvent
Timing and spatial scale	The study assesses climate impacts over 100 years (GWP100) and 20 years (GWP20). Supply chain assessments were constrained to Texas.
Data exclusions	N/A
Reproducibility	Methods used to conduct this analysis were thoroughly described. Additionally, no proprietary data used was uploaded to a data repository
Randomization	N/A
Blinding	N/A

Did the study involve field work? ☐ Yes ☒ No

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Plants

Seed stocks

N/A

Novel plant genotypes

N/A

Authentication

N/A