Metadata

Data and code for 'Worldwide greenhouse gas emissions of green hydrogen'

In our paper 'Worldwide greenhouse gas emissions of green hydrogen', we quantify project-specific greenhouse gas emissions for 1,025 green hydrogen projects in 2030, as well as green hydrogen transport emissions for three transport modes: pipeline, liquid hydrogen shipping and ammonia shipping. This repository entry contains the data and code used to produce the outputs presented in the paper.

Code

It contains three R scripts used to calculate the production and transport emissions, one for each hydrogen production configuration:

Hydrogen_export.R
Used for the *Grid-connected: power export* configuration.

Hydrogen_import.R
Used for the *Grid-connected: power import* configuration.

Hydrogen_curtailment.R
Used for the *Off-grid: curtailment* configuration.

The output of these scripts are the input to create the figures, for which the scripts are: **Figure1.R, Figure2.R, Figure3_solar.R, Figure3_wind.R, Figure4.R, Figure5.R, Figure6A.R, and Figure6BC.R.**

Data

The data used to produce the outputs is also included in this repository.

Note: Although we generally use country-specific information, for the calculations, for six projects in the IEA Hydrogen Projects Database (2022), multiple countries are given as the location. For these cases, we include multi-country averages of the wind and solar capacity factors, wind speeds, solar irradiation, and modelled grid mix greenhouse gas intensities. These averages are included in the data files described below.

Country_continent_codes.csv
Contains continent names for each country, and the water stress score for all countries in which a hydrogen project is located. Country-level water stress scores are from the World Resources Institute, published by Hofste, R. et al. (2019). Aqueduct 3.0: Updated Decision-Relevant Global Water Risk Indicators, https://doi.org/10.46830/writn.18.00146.

Country_offshore_wind_capacity_output.csv
Contains the wind capacity factors for each country for the offshore area using capacity-factor_iec3, covering the exclusive economic zone (EEZ). The min, 10th percentile, 25th percentile, mean, 75th percentile, 90th percentile and max capacity factor are included. Data

is based on the Global Wind Atlas 3.0, https://globalwindatlas.info. For six projects in the IEA Hydrogen Project Database (2022), multiple countries are given as the location: for these cases, we include multi-country averages of the wind capacity factors.

Country_offshore_wind_output.csv
Contains the min, 10th percentile, 25th percentile, mean, 75th percentile, 90th percentile and max wind speed at 100 m in m/s, covering each country's exclusive economic zone (EEZ). Data is based on the Global Wind Atlas 3.0, https://globalwindatlas.info. For six projects in the IEA Hydrogen Project Database (2022), multiple countries are given as the location: for these cases, we include multi-country averages of the wind speed.

Country_wind_capacity_output.csv
Contains the wind capacity factors for each country for onshore area using capacity-factor_iec1. The min, 10th percentile, 25th percentile, mean, 75th percentile, 90th percentile and max capacity factor are included. Data is based on the Global Wind Atlas 3.0, https://globalwindatlas.info.

Country_wind_output.csv
Contains the min, 10th percentile, 25th percentile, mean, 75th percentile, 90th percentile and max wind speed at 100 m in m/s, covering each country's territory. Data is based on the Global Wind Atlas 3.0, https://globalwindatlas.info.

EEZ_wind_output_no_overlap.csv
Contains the wind capacity factors for each country for the offshore area using capacity-factor_iec3, covering the exclusive economic zone (EEZ), and is used for Figure 3. The min, 10th percentile, 25th percentile, mean, 75th percentile, 90th percentile and max capacity factor are included. Data is based on the Global Wind Atlas 3.0, https://globalwindatlas.info.

FTT_elec_data_countries_3107.csv
Contains the greenhouse gas intensities (gCO_2-eq/kWh) of national 2030 grid mixes modelled for a 2°C policy scenario, published by Knobloch, F. et al. (2020). Net emission reductions from electric cars and heat pumps in 59 world regions over time. *Nat Sustain* 3, 437–447, https://doi.org/10.1038/s41893-020-0488-7; and water stress score for all countries in which a hydrogen project is located. Country-level water stress scores are from the World Resources Institute, published by Hofste, R. et al. (2019). Aqueduct 3.0: Updated Decision-Relevant Global Water Risk Indicators, https://doi.org/10.46830/writn.18.00146.

Hydroelectricity.csv
Contains mean greenhouse gas intensity of hydroelectricity (gCO_2-eq/kWh) for different facility types and sizes based on Kadiyala, A., et al. (2016). Evaluation of the life cycle greenhouse gas emissions from hydroelectricity generation systems. *Sustain.* 8, 1–14, https://doi.org/10.3390/su8060539.

IEA_2022_Hydrogen_db.csv
Contains hydrogen facility-specific information on electricity source, electrolyser technology, location, and project size, from the Hydrogen Projects Database (version of October 2022) from the International Energy Agency (IEA) (accessible via: https://www.iea.org/data-andstatistics/data-product/hydrogen-projects-database), with additional information included on the type of hydroelectricity facility.

Knobloch_grid_2030.csv
Contains the greenhouse gas intensities (gCO_2-eq/kWh) of national 2030 grid mixes modelled for a 2°C policy scenario, published by Knobloch, F. et al. (2020). Net emission

reductions from electric cars and heat pumps in 59 world regions over time. *Nat Sustain* 3, 437–447, https://doi.org/10.1038/s41893-020-0488-7.

Market_shares_panel_types.csv
Contains the market shares of solar photovoltaic panels, as a weighted average based on the year-specific market mix. These are derived using data from Bosmans, J. et al. (2021). Greenhouse gas footprints of utility-scale photovoltaic facilities at the global scale. *Environ. Res. Lett.* 16, 094056, https://doi.org/10.1088/1748-9326/ac1df9, and data from Fraunhofer ISE (2022) *Photovoltaics Report*.

match_country_Knobloch.csv
For each country code used in the IEA database, this includes the matching country/region name that Knobloch, F. et al. (2020) use for modelling grid electricity greenhouse gas intensity.

solargis_pv_irradiation.csv
Contains the global horizontal irradiation (GHI, kWh/m^2/day) per country, covering latitudes from parallel 45°S up to parallel 60°N. The min, 10th percentile, 25th percentile, average, 75th percentile, 90th percentile and max irradiation are included. Data is from the Global Solar Atlas 2.0, https://globalsolaratlas.info.

solargis_pv_output_potential.csv
Contains the power output (kWh/kWp/day) per country, from which the capacity factor can be calculated. It covers latitudes from parallel 45°S up to parallel 60°N, and includes the min, 10th percentile, 25th percentile, average, 75th percentile, 90th percentile and max power output are included. Data is from the Global Solar Atlas 2.0, https://globalsolaratlas.info.

WindTurbineGHGData.csv
Contains wind turbine data collected and analysed by Dammeier, L.C. et al. (2023). Variability in greenhouse gas footprints of the global wind farm fleet. *J. Ind. Ecol.* 27, 272–282, https://doi.org/10.1111/jiec.13325.