Package ‘kayadata’

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Type    Package
Title   Kaya Identity Data for Nations and Regions
Version 1.3.0
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Description Provides data for Kaya identity variables (population, gross domestic product, primary energy consumption, and energy-related CO2 emissions) for the world and for individual nations, and utility functions for looking up data, plotting trends of Kaya variables, and plotting the fuel mix for a given country or region. The Kaya identity (Yoichi Kaya and Keiichi Yokobori, "Environment, Energy, and Economy: Strategies for Sustainability" (United Nations University Press, 1998) and <https://en.wikipedia.org/wiki/Kaya_identity>) expresses a nation's or region's greenhouse gas emissions in terms of its population, per-capita Gross Domestic Product, the energy intensity of its economy, and the carbon-intensity of its energy supply.

URL https://jonathan-g.github.io/kayadata/,
https://github.com/jonathan-g/kayadata,
https://doi.org/10.5281/zenodo.8144476

BugReports https://github.com/jonathan-g/kayadata/issues

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Depends R (>= 3.5), ggplot2 (>= 3.0)
Imports magrittr (>= 1.5), forcats (>= 0.3), dplyr (>= 0.8), tidyr (>= 0.8), stringr (>= 1.3), scales (>= 1.0), purrr (>= 0.3)

Encoding UTF-8

Language en-US

LazyData true

RoxygenNote 7.2.3

Suggests broom (>= 0.5), knitr (>= 1.22), rmarkdown (>= 1.12), testthat (>= 2.0), vdiffir (>= 0.3.1)
**Description**

kayadata is a package for working with Kaya identity data for many countries and regions. The Kaya identity, named for the economist Yoichi Kaya, who introduced it (Kaya, 1998); it decomposes the energy-related carbon dioxide emissions from a nation, region, or the world into the product of four components:

\[ F = P \times g \times e \times f, \]

where \( F \) is the total emissions, \( P \) is the population, \( g \) is the per-capita GDP, \( e \) is the energy intensity of the economy, and \( f \) is the emissions-intensity of the energy supply. (Nakicenovic and Swart, 2000, Ch. 3, p. 105; Raupach et al, 2007)

The package uses data on population and GDP from the World Bank, using market exchange rates (MER) for GDP because those data go back to 1960. From 1990 onward, Purchasing-Power-Parity (PPP) GDP figures are available as \( G_{\text{ppp}} \) but using these would require re-calculating \( G, g, e \), and \( ef \) in the \texttt{kayadata} data frame.

The package uses data on energy consumption and fossil-fuel CO2 emissions from the Energy Institute's 2023 Statistical Review of World Energy

**License**

The \texttt{kayadata} package is open source licensed under the MIT License.

**Bug reports**

- \texttt{kayadata issue tracker} (https://github.com/jonathan-g/kayadata/issues)

**References**


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**emissions_factors**

Get emission factors for different energy sources

**Description**

Get emission factors for different energy sources

**Usage**

\[
\text{emissions\_factors}(\text{collapse\_renewables} = \text{TRUE})
\]

**Arguments**

- \text{collapse\_renewables}
  
  Combine hydroelectricity and other renewables into a single category.

**Value**

A tibble of values for emissions factors, in million metric tons of carbon dioxide per quad of energy.

**See Also**

\texttt{regions}
Examples

```r
e_fac <- emissions_factors()
e_fac
```

---

**fuel_mix**

*Mix of fuels contributing to primary energy supply for many countries and regions*

**Description**

A dataset containing the fuel mix of how many quads and what fraction of total primary energy supply comes from coal, gas, oil, nuclear, and renewable sources.

**Usage**

```r
fuel_mix
```

**Format**

A tibble containing 948 rows and 7 variables

- **region** Country or region name
- **region_code** Three-letter country or region code
- **geography** Geographic category: "nation", "region", or "world"
- **year** The year
- **fuel** The fuel: "Coal", "Natural Gas", "Oil", "Nuclear", "Hydro", and "Renewables"
- **quads** The number of quads of that fuel consumed in the given country or region and year
- **frac** The fraction of that country or region’s total primary energy consumption from the fuel

**Note**

The 2023 data from the Energy Institute has inconsistencies in the fuel mix for Hong Kong and Sri Lanka: The percentages add up to 98.7% and 102.9%, respectively. The sums of energy in quads are off by -0.095 and +0.095 quads, respectively, from the total energy figure.

**Source**


**See Also**

`regions`, `get_fuel_mix()`
**generation_capacity**  

*Get power output from generation sources*

**Description**

Nameplate capacity and capacity factors for different electrical generation technologies. The average power supplied over a year is the nameplate capacity times the capacity factor.

**Usage**

```r
generation_capacity()
```

**Details**

Data for fossil fuels comes from EIA

**Value**

a tibble of values for generation sources

- **fuel**  
  Energy source: Coal, Nuclear, Gas, Solar Thermal, Solar Photovoltaic, Onshore Wind, or Offshore Wind

- **description**  
  Text description of the power source

- **nameplate_capacity**  
  Maximum sustained power output, in megawatts

- **capacity_factor**  
  Capacity factor: the fraction of the nameplate capacity that the plant can provide, averaged over a typical year

**References**


**Examples**

```r
gc <- generation_capacity()
gc
```
get_fuel_mix

Description
Get fuel mix for one or more countries or regions

Usage
get_fuel_mix(
  region_name,
  collapse_renewables = TRUE,
  quiet = FALSE,
  region_code = NULL
)

Arguments
region_name A character vector with the names of one or more countries or regions to look up
collapse_renewables Combine hydroelectricity and other renewables into a single category.
quiet Suppress warnings if there is no data for that country or region.
region_code Optional three-letter country or region codes to look up instead of the region_name

Value
A tibble of fuel mix for the countries or regions specified. That is, the number of quads of each fuel and the fraction of total primary energy coming from that fuel for each country or region:

  region  The name of the country or region
  year    The year reported
  fuel    The name of the fuel
  quads   The number of quads per year the country or region consumes
  frac    The fraction of the country’s energy that comes from that fuel

Note
In the latest data from the Energy Institute, there are small discrepancies between the sums of energy for each fuel and the totals, in both quads and frac, for Hong Kong and Sri Lanka, as described in the documentation for fuel_mix.

See Also
regions, fuel_mix
**get_kaya_data**

Examples

get_fuel_mix("United States")
get_fuel_mix("World", collapse_renewables = FALSE)
get_fuel_mix(region_code = "LCN")

---

**get_kaya_data**

Get Kaya data for one or more countries or regions

Description

Get Kaya data for one or more countries or regions

Usage

get_kaya_data(
  region_name,
  gdp = c("MER", "PPP"),
  quiet = FALSE,
  region_code = NULL
)

Arguments

- **region_name**: The name of one or more countries or regions to look up
- **gdp**: Use market exchange rates (MER) or purchasing power parity (PPP). Default is MER.
- **quiet**: Suppress warnings if there is no such country or region.
- **region_code**: Optional three-letter country or region codes to look up instead of the region_name

Details

Units for \( G, g, e, \) and \( ef \) depend on whether the data is requested in MER or PPP dollars: For MER, dollars are constant 2015 U.S. dollars. For PPP, dollars are constant 2017 international dollars.

\[ P_\] and MER values for GDP and related quantities are available from 1960 onward.

PPP values for GDP and related quantities are only available from 1990 onward.

Energy-related values (\( E, f, \), and derived quantities) are available from 1965 onward.

Note that emissions (\( f, _f, \), and \( ef \)) are reported as millions of metric tons of carbon dioxide, not carbon.
get_top_down_trends

top-down trends for Kaya variables for one or more countries or regions, using projections from U.S. Energy Information Administration’s International Energy Outlook report.

Description

Get top-down trends for Kaya variables for one or more countries or regions, using projections from U.S. Energy Information Administration’s International Energy Outlook report.

Usage

get_top_down_trends(region_name, quiet = FALSE, region_code = NULL)

Arguments

region_name The name of one or more countries or regions to look up
quiet Suppress warnings if there is no data for the specified countries or regions.
region_code Optional three-letter country or region codes to look up instead of the region_name
get_top_down_values

Value

a tibble of trends for P, G, E, F, g, e, f, and ef for each country or region in percent per year.

See Also

regions

Examples

get_top_down_trends("Spain")
get_top_down_trends(region_code = "RUS")

get_top_down_values

Get top-down projections of Kaya variables for one or more countries or regions

Description

Get top-down projections of Kaya variables for one or more countries or regions

Usage

get_top_down_values(region_name, quiet = FALSE, region_code = NULL)

Arguments

region_name The name of a country or region to look up
quiet Suppress warnings if there is no data for that country or region.
region_code Optional three-letter country or region code to look up instead of the region_name

Value

a tibble of values for P, G, E, F, g, e, f, and ef for each country or region:

region  The name of the country or region
P  Population, in billions
E  Total primary energy consumption, in quads
F  CO2 emissions from fossil fuel consumption, in millions of metric tons
g  Per-capita GDP, in thousands of constant 2015 U.S. dollars per person.
e  Energy intensity of the economy, in quads per trillion dollars.
f  Emissions intensity of the energy supply, in million metric tons per quad.
ef  Emissions intensity of the economy, in metric tons per million dollars of GDP.
See Also

regions

Examples

get_top_down_values("New Zealand")
get_top_down_values("OECD")
get_top_down_values(region_code = "PAK")

kaya_data

Kaya identity data for many countries and regions

Description

A dataset containing Kaya identity parameters P, G, E, F, g, e, f, and ef for many countries

Usage

kaya_data

Format

A tibble containing 5292 rows and 14 variables:

region Country or region name
region_code Three-letter country or region code
g Geography Geographic category: "nation", "region", or "world"
year The year
P Population, in billions
E Total primary energy consumption, in quads
F CO2 emissions from fossil fuel consumption, in millions of tons
g Per-capita GDP, in thousands of constant 2015 U.S. dollars per person.
e Energy intensity of the economy, in quads per trillion dollars.
f Emissions intensity of the energy supply, in million metric tons per quad.
G_ppp Gross domestic product adjusted for purchasing power parity, in trillions of constant 2017 international dollars
G_mer Gross domestic product at market-exchange-rate, in trillions of constant 2015 U.S. dollars

Source

kaya_region_list

See Also
regions, get_kaya_data()

---

kaya_region_list    Get a list of countries in the Kaya data

Description
Get a list of countries in the Kaya data

Usage
kaya_region_list()

Value
a vector of country and region names

See Also
regions

---

megawatts_per_quad    The number of megawatts it takes to replace a quad.

Description
The number of megawatts of average power output over a year to produce one quad of energy

Usage
megawatts_per_quad()

Value
The number of megawatts equivalent to one quad per year.

Examples
mwe <- megawatts_per_quad()
mwe
plot_fuel_mix

Description

Plot fuel mix

Usage

plot_fuel_mix(
  fuel_mix,
  collapse_renewables = TRUE,
  title = NULL,
  colors = NULL,
  font_size = 20
)

Arguments

fuel_mix A tibble with the mixture of fuels for one or more countries or regions:
  region The name of the country or region
  fuel The name of the fuel
  quads The number of quads per year the country or region consumes
  frac The fraction of the country’s energy that comes from that fuel

collapse_renewables
  Combine hydroelectricity and other renewables into a single category.

title
  Include a title on the plot. If title is NULL (default) or TRUE, a default title is created from the names of the regions in fuel_mix. If title is a character string, that string is used. If title is FALSE, the plot is produced with no title.

colors A named vector with the colors to use for Coal, Oil, Natural Gas, Nuclear, Hydro, and Renewables.

font_size The base font size.

Value

A plot object.

Examples

usa_fuel <- get_fuel_mix("United States", collapse_renewables = FALSE)
plot_fuel_mix(usa_fuel)
plot_fuel_mix(usa_fuel, collapse_renewables = FALSE)
plot_fuel_mix(usa_fuel, collapse_renewables = FALSE,
  colors = c(Coal = "black", "Natural Gas" = "gray60",
            Oil = "gray30", Nuclear = "forestgreen",
            Hydro = "royalblue", Renewables="palegreen"))
Description

Plot Kaya-identity variable

Usage

plot_kaya(
  kaya_data,
  variable,
  start_year = NA,
  stop_year = NA,
  y_lab = NULL,
  log_scale = FALSE,
  trend_line = FALSE,
  points = TRUE,
  font_size = 20,
  colors = NULL,
  pre_color = NULL,
  post_color = NULL,
  in_range_color = NULL,
  trend_color = NULL,
  line_sizes = NULL,
  pre_line_size = NULL,
  post_line_size = NULL,
  in_range_line_size = NULL,
  trend_line_size = NULL,
  point_sizes = NULL,
  pre_point_size = NULL,
  post_point_size = NULL,
  in_range_point_size = NULL
)

Arguments

- `kaya_data`: A tibble with Kaya-identity data
- `variable`: The name of the variable to plot (character)
- `start_year`: The year to start highlighting the data (should correspond to the beginning of the trend calculation). Set to NULL to turn off highlighting.
- `stop_year`: The year to stop highlighting the data (should correspond to the beginning of the trend calculation). Set to NULL to turn off highlighting.
- `y_lab`: Optional label for the y-axis
- `log_scale`: Use log scale for y axis
trend_line  Include a trend line
points     Plot points in addition to the line.
font_size  Base size of the font for axis labels and titles.
colors     Named vector of colors to use for the plot. Elements should include PRE, POST, IN-RANGE, and TREND, which respectively give the colors for the portion of the plot before start_year, after stop_year, between start_year and stop_year, and the trend line.
pre_color  Override default color for the portion of the chart before start_year.
post_color Override default color for the portion of the chart after stop_year.
in_range_color Override default color for the portion of the chart between start_year and stop_year.
trend_color Override default color for the trend line.
line_sizes Named vector of sizes to use for the lines in the plot. Elements should include PRE, POST, IN-RANGE, and TREND, which respectively give the sizes for lines in the portion of the plot before start_year, after stop_year, between start_year and stop_year, and the trend line.
pre_line_size Override default line size for the portion of the chart before start_year.
pref_line_size Override default line size for the portion of the chart after stop_year.
in_range_line_size Override default line size for the portion of the chart between start_year and stop_year.
trend_line_size Override default size for the trend line.
point_sizes Named vector of sizes to use for the points in the plot. Elements should include PRE, POST, and IN-RANGE, which respectively give the sizes for points in the portion of the plot before start_year, after stop_year, and between start_year and stop_year.
pre_point_size Override default point size for the portion of the chart before start_year.
pref_point_size Override default point size for the portion of the chart after stop_year.
in_range_point_size Override default point size for the portion of the chart between start_year and stop_year.

Value
A plot object.

Examples
china <- get_kaya_data("China")
plot_kaya(china, "F", 2001, 2011)
## Not run:
uk <- get_kaya_data("United Kingdom")
plot_kaya(uk, "e", log_scale = TRUE, trend_line = TRUE)
project_top_down

Get top-down projections of Kaya variables for one or more countries or regions for a given year

Description

Get top-down projections of Kaya variables for one or more countries or regions for a given year.

Usage

project_top_down(region_name, year, quiet = FALSE, region_code = NULL)

Arguments

region_name The name of a country or region to look up
year The year to project to
quiet Suppress warnings if there is no data for that country or region.
region_code Optional three-letter country or region code to look up instead of the region_name

Value

A tibble of values for P, G, E, F, g, e, f, and ef for each country or region:

region The name of the country or region
year The year
P Population, in billions
E Total primary energy consumption, in quads
F CO2 emissions from fossil fuel consumption, in millions of metric tons

g Per-capita GDP, in thousands of constant 2015 U.S. dollars per person.

e Energy intensity of the economy, in quads per trillion dollars.

f Emissions intensity of the energy supply, in million metric tons per quad.

ef Emissions intensity of the economy, in metric tons per million dollars of GDP.

See Also

regions

Examples

project_top_down("China", 2037)

project_top_down(region_code = "VNM", year = 2043)

regions  Aggregate regional data

Description

Problems with aggregate regional data

Details

The World Bank is missing GDP data for a number of nations, such as Syria and Taiwan. Because of this and the incommensurability between the regions used for aggregate statistics in the World Bank and Energy Institute data, aggregate regional data (e.g., for the Middle East and Africa) should be treated with caution. This problem does not hold for individual nations, where missing data appears as NA values.

td_trends  Top-down projections of trends in Kaya variables for many countries and regions

Description


Usage

td_trends
Format

A tibble containing 226 rows and 11 variables

region Country or region name
region_code Three-letter country or region code
geography Geographic category: "nation", "region", or "world"
P Trend in population, in fraction per year
G Trend in gross domestic product, in fraction per year
E Trend in total primary energy consumption, in fraction per year
F Trend in CO2 emissions, in fraction per year
g Trend in per-capita GDP, in fraction per year
e Trend in energy intensity of the economy, in fraction per year
f Trend in emissions intensity of the economy, in fraction per year
ef Trend in emissions intensity of the economy, in fraction per year

Source

https://www.eia.gov/outlooks/archive/ieo17/

See Also

regions, get_top_down_trends()

---

<table>
<thead>
<tr>
<th>td_values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top-down projections of future Kaya variables for many countries and regions</td>
</tr>
</tbody>
</table>

Description


Usage

td_values

Format

A tibble containing 640 rows and 12 variables

region Country or region name
region_code Three-letter country or region code
geography Geographic category: "nation", "region", or "world"
year The year
**P** Population, in billions

**G** Gross domestic product, in trillions of constant 2015 U.S. dollars

**E** Total primary energy consumption, in quads

**F** Total CO2 emissions, in millions of metric tons

**g** Per-capita GDP, in thousands of constant 2015 U.S. dollars per person.

**e** Energy intensity of the economy, in quads per trillion dollars.

**f** Emissions intensity of the energy supply, in million metric tons per quad.

**ef** Emissions intensity of the economy, in metric tons per million dollars of GDP.

**Source**

https://www.eia.gov/outlooks/archive/ieo17/

**See Also**

regions, get_top_down_values()
Index

* datasets
  fuel_mix, 4
  kaya_data, 10
  td_trends, 16
  td_values, 17

emissions_factors, 3
fuel_mix, 4, 6

generation_capacity, 5
get_fuel_mix, 6
get_fuel_mix(), 4
get_kaya_data, 7
get_kaya_data(), 11
get_top_down_trends, 8
get_top_down_trends(), 17
get_top_down_values, 9
get_top_down_values(), 18

kaya_data, 10
kaya_region_list, 11
kayadata-package, 2

megawatts_per_quad, 11
plot_fuel_mix, 12
plot_kaya, 13
project_top_down, 15

regions, 3, 4, 6, 8–11, 16, 16, 17, 18

td_trends, 16
td_values, 17