

# Package ‘kayadata’

January 8, 2020

**Type** Package

**Title** Kaya Identity Data for Nations and Regions

**Version** 0.4.3

**Date** 2019-12-21

**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](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>

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

**License** MIT + file LICENSE

**Depends** R (>= 3.5), ggplot2 (>= 3.0)

**Imports** magrittr (>= 1.5), forcats (>= 0.3), dplyr (>= 0.8), tidyr (>= 0.8), stringr (>= 1.3.1), scales (>= 1.0)

**Encoding** UTF-8

**Language** en-US

**LazyData** true

**RoxygenNote** 7.0.2

**Suggests** broom (>= 0.5), knitr (>= 1.22), purrr (>= 0.3), rmarkdown (>= 1.12), testthat (>= 2.0), vdiffr (>= 0.3.1)

**VignetteBuilder** knitr

**NeedsCompilation** no

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kayadata-package	<i>kayadata package</i>
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## 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 data in this packages covers 1960-2018 for population and GDP, and 1965-2018 for energy and fossil-fuel CO2 emissions.

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\_ppp but using these would require re-calculating G, g, e, and ef in the kaya\_data data frame.

The package uses data on energy consumption and fossil-fuel CO2 emissions from the [2019 BP Statistical Review of World Energy](#)

### License

The **kayadata** package is open source licensed under the MIT License.

### Bug reports

- kayadata issue tracker (<https://github.com/jonathan-g/kayadata/issues>)

### References

Kaya, Yoichi and Keiichi Yokobori, *Environment, Energy, and Economy: Strategies for Sustainability* (United Nations University Press, 1998).

Nakicenovic, Nebojsa, and Rob Swart (Eds.), *Special Report on Emissions Scenarios* (Cambridge University Press, 2000). <https://www.ipcc.ch/report/emissions-scenarios/>

Raupach, Michael R., *et al.*, "Global and regional drivers of accelerating CO2 emissions," *PNAS* **104**, 10288–10293 (2007) doi: [10.1073/pnas.0700609104](https://doi.org/10.1073/pnas.0700609104).

---

emissions\_factors      *Get emission factors for different energy sources*

---

### Description

Get emission factors for different energy sources

### Usage

```
emissions_factors()
```

### Value

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

### Examples

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

---

fuel_mix	<i>Mix of fuels contributing to primary energy supply for many countries and regions</i>
----------	--

---

### 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

```
fuel_mix
```

### Format

A tibble containing 936 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

### Source

<https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/downloads.html>

---

generation_capacity	<i>Get power output from generation sources</i>
---------------------	---

---

### 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

```
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, or 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**

Environmental Protection Agency (2018) "Electric Power Monthly," (October 2018) [https://www.eia.gov/electricity/monthly/current\\_month/epm.pdf](https://www.eia.gov/electricity/monthly/current_month/epm.pdf), Table 6.7.A.

Pielke, Jr., Roger A., *The Climate Fix* (Basic Books, 2010).

**Examples**

```
gc <- generation_capacity()
gc
```

---

get\_fuel\_mix

*Get fuel mix for one or more countries or regions*

---

**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

**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 2010 U.S. dollars. For PPP, dollars are constant 2011 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.

## Value

a tibble of Kaya identity data for the countries or regions specified:

**region** The name of the country or region

**year** The year

**P** Population, in billions

**G** Gross domestic product, in trillions of constant 2010 U.S. dollars.

**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 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.

## Examples

```
get_kaya_data("Brazil")
get_kaya_data("United Kingdom", "PPP")
get_kaya_data(region_name = "United States")
get_kaya_data(region_code = "MYS")
```

---

get_top_down_trends	<i>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.</i>
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---

### 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

### Value

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

### Examples

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

---

get_top_down_values	<i>Get top-down projections of Kaya variables for one or more countries or regions</i>
---------------------	--

---

### 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

**G** Gross domestic product, in trillions of constant 2010 U.S. dollars.

**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 2010 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.

**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 5133 rows and 14 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 2010 U.S. dollars.

**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 2010 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.
- G\_ppp** Gross domestic product adjusted for purchasing power parity, in trillions of constant 2011 international dollars
- G\_mer** Gross domestic product at market-exchange-rate, in trillions of constant 2010 U.S. dollars

### Source

<https://data.worldbank.org/indicator/SP.POP.TOTL>, <https://data.worldbank.org/indicator/NY.GDP.MKTP.KD>, and <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy-outlook/downloads.html>

---

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

---

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	<i>Plot fuel mix</i>
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---

### Description

Plot fuel mix

### Usage

```
plot_fuel_mix(
  fuel_mix,
  collapse_renewables = TRUE,
  title = NULL,
  colors = NULL
)
```

### Arguments

fuel_mix	A tibble with the mixture of fuels for one or more countries or regions:
<b>region</b>	The name of the country or region
<b>fuel</b>	The name of the fuel
<b>quads</b>	The number of quads per year the country or region consumes
<b>frac</b>	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.

### 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"))
```

---

plot_kaya	<i>Plot Kaya-identity variable</i>
-----------	------------------------------------

---

**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
)
```

**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.

**Value**

A plot object.

**Examples**

```
china <- get_kaya_data("China")
plot_kaya(china, "F", 2001, 2011)
uk <- get_kaya_data("United Kingdom")
plot_kaya(uk, "e", log_scale = TRUE, trend_line = TRUE)
plot_kaya(uk, "e", log_scale = TRUE, trend_line = TRUE,
          start_year = 1970, stop_year = 2000,
          colors = c(PRE="limegreen", POST="darkgreen",
                    "IN-RANGE" = "cadetblue", TREMD="orange"))
plot_kaya(uk, "e", log_scale = TRUE, trend_line = TRUE,
          start_year = 1970, stop_year = 2000,
          pre_color = "limegreen", post_color = "limegreen",
          trend_color = "magenta")
world <- get_kaya_data("World")
plot_kaya(world, "g", 1982, log_scale = TRUE, trend_line = TRUE)
```

---

project_top_down	<i>Get top-down projections of Kaya variables for one or more countries or regions for a given year</i>
------------------	---

---

**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

**G** Gross domestic product, in trillions of constant 2010 U.S. dollars.

**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 2010 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.

**Examples**

```
project_top_down("China", 2037)
project_top_down(region_code = "VNM", year = 2043)
```

---

td_trends	<i>Top-down projections of trends in Kaya variables for many countries and regions</i>
-----------	--

---

**Description**

A dataset containing top-down projections of trends in P, G, and E, from the EIA's International Energy Outlook 2017.

**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 energy supply, in fraction per year
- ef** Trend in emissions intensity of the economy, in fraction per year

### Source

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

---

td_values	<i>Top-down projections of future Kaya variables for many countries and regions</i>
-----------	---

---

### Description

A dataset containing top-down projections of P, G, and E, from the EIA's International Energy Outlook 2017.

### Usage

td\_values

### Format

A tibble containing 648 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 2010 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 2010 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/>

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