

GHG

Emissions:  
Making Sense  
of Big  
Numbers  
and Interna-  
tional/Historica  
Contexts

Dave Feldman

Emissions

Emissions &  
Warming

Cumulative  
Emissions

Climate &  
Energy

Conclusion

# GHG Emissions: Making Sense of Big Numbers and International/Historical Contexts

David P. Feldman

College of the Atlantic

14 January 2021

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- 3 Cumulative Emissions
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- 5 Conclusion

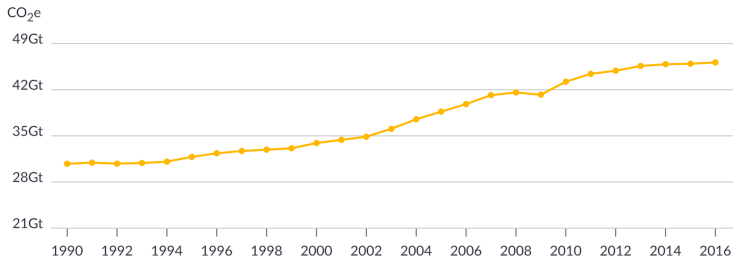
- Develop emissions benchmarks to contextualize emissions numbers
- Show some ways to make numbers meaningful
  - Make numbers memorable and relatable
  - Some interesting and clever graphs
- Think about responsibility for emissions

- Greenhouse gases (GHG)—mainly  $\text{CO}_2$ —are warming the planet
- It is like adding blankets to the planet. More blankets increase the equilibrium temperature.
- **These effects are cumulative.**
- The blankets last “forever” .
- So to stop climate change, we need to stop emitting GHG.

## Historical GHG emissions

CLIMATEWATCH

Data source: CAIT; Countries/Regions: World; Sectors/Subsectors: Total excluding LUCF; Gases: All GHG; Calculation: Total; Show data by Regions.



2016 worldwide emissions of CO<sub>2</sub>e is 46 Giga tonnes!!

World

# World Emissions—Numbers and a Rectangle

- 2016 CO<sub>2</sub> global emissions: 46 Gt

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# World Emissions—Numbers and a Rectangle

- 2016 CO<sub>2</sub> global emissions: 46 Gt
- 1 giga = 1 billion = 10<sup>9</sup>

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# World Emissions—Numbers and a Rectangle

- 2016 CO<sub>2</sub> global emissions: 46 Gt
- 1 giga = 1 billion =  $10^9$
- 2016 population: 7.4 Gp (giga people)



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- 2016 global emissions:  $\frac{46Gt}{7.4Gp} \approx 6$  tonnes  
CO<sub>2</sub>e/person

# World Emissions—Numbers and a Rectangle

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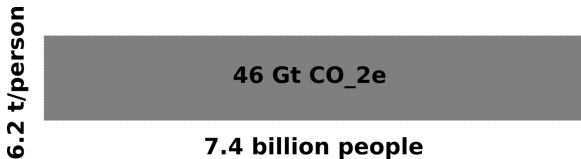
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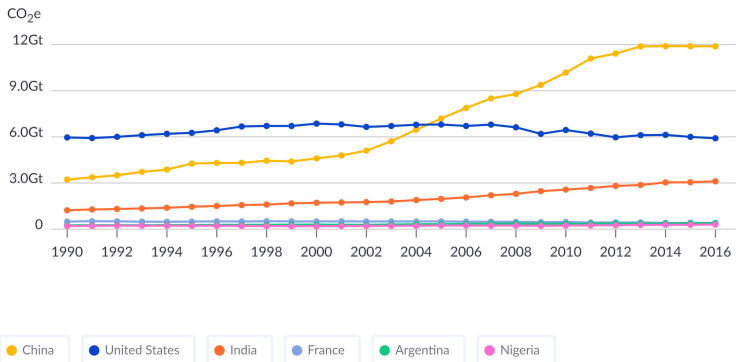
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## Historical GHG emissions

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Data source: CAIT; Countries/Regions: Argentina, China, France, India, Nigeria, United States; Sectors/Subsectors: Total excluding LUCF; Gases: All GHG; Calculation: Total; Show data by Countries.



- 2016 CO<sub>2</sub> US emissions:  $\approx 6$  Gt

# Numbers and a Rectangle for the US

- 2016 CO<sub>2</sub> US emissions:  $\approx 6$  Gt
- 2016 population:  $\approx 330$  million =  $\frac{1}{3}$  Gp (giga people)

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- 2016 population:  $\approx 330 \text{ million} = \frac{1}{3} \text{ Gp}$  (giga people)
- 2016 global emissions:  $\frac{6 \text{ Gt}}{1/3 \text{ Gp}} \approx 18 \text{ tonnes CO}_2\text{e/person}$

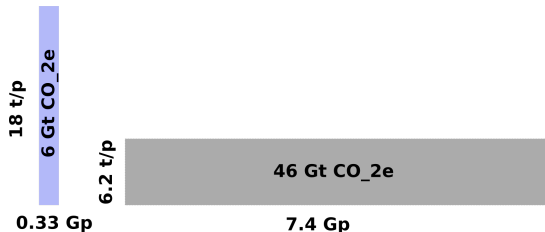
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# Selected Country Emissions *per capita*

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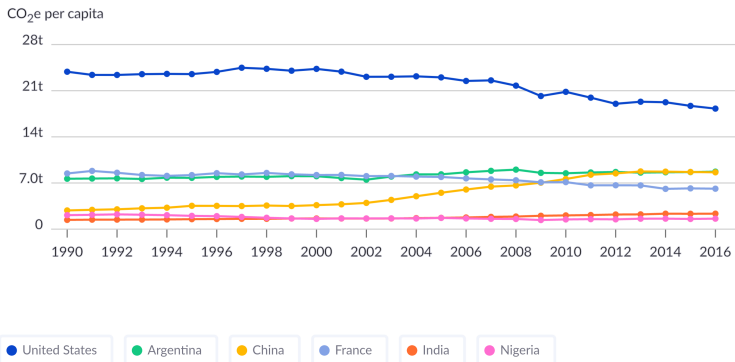
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## Historical GHG emissions

**CLIMATEWATCH**

Data source: CAIT; Countries/Regions: Argentina, China, France, India, Nigeria, United States; Sectors/Subsectors: Total excluding LUCF; Gases: All GHG; Calculation: per Capita; Show data by Countries.



# Emissions by Country (CO<sub>2</sub> and not CO<sub>2e</sub>)

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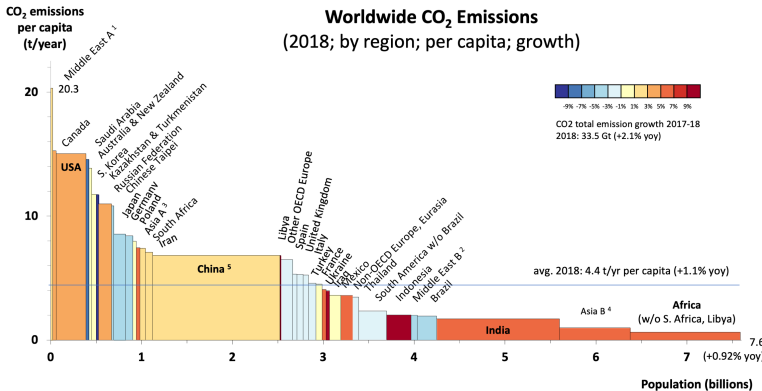
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**Notes:**

Emission-related CO<sub>2</sub> emissions only; no other greenhouse gases or natural sources; aviation and marine bunkers not shown as territory, but included in average and totals.

<sup>1</sup> Middle East A: Bahrain, Oman, Kuwait, Qatar, United Arab Emirates

<sup>2</sup> Middle East B: Israel, Jordan, Lebanon, Syrian Arab Republic, Yemen

<sup>3</sup> Asia A: Brunei Darussalam, Malaysia, Mongolia, Singapore

<sup>4</sup> Asia B: Asia without Asia A, China, India, Thailand, Chinese Taipei, Indonesia, S. Korea, Japan

<sup>5</sup> China: People's Rep. of China, Hong Kong

**Attribution:**

Based on IEA data from IEA (2020) "CO<sub>2</sub> Emissions from Fuel Combustion 2020", [www.iea.org/statistics](http://www.iea.org/statistics). All rights reserved; as modified by Thomas Schulz, AQAL Capital GmbH.

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area. This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.

**Version:**

25-Oct-2020 by Thomas Schulz, AQAL Capital GmbH (<https://aqalcapital.com>)



# Measurement Details—Mostly Not Important for Big Picture

- CO<sub>2</sub> or all GHGs (methane, nitrous oxide, ...)
  - Other GHGs converted to CO<sub>2</sub> equivalent (CO<sub>2e</sub>)
- Include emissions associated with land use change and forestry (LUCF)?
- IPCC estimates that emissions numbers accurate\* within 10%.
- Include only emissions from burning fossil fuels?
- Ecologists measure C instead of CO<sub>2</sub>. (One ton of C  $\approx$  3.7 tons of CO<sub>2</sub>.)
- How account for international transport?

# Emissions vs Warming

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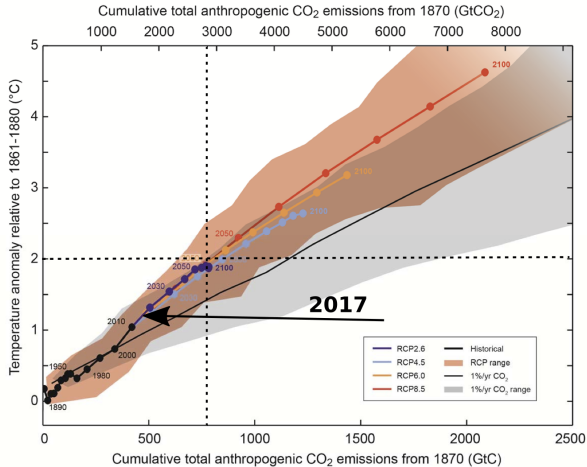
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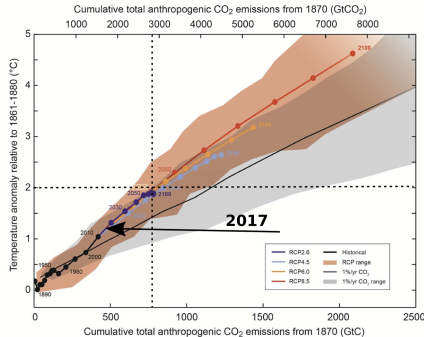
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- Warming vs. emissions approximately linear
- $\approx 1000$  Gt remaining before 2C of warming

# Emissions vs Warming



- Some disagreement over how many Gt we can emit before 2C of warming
- But regardless, we need to transition to **zero emissions**
- (Figure: IPPP AR5 Report Figure SPM10)

# How to Keep Warming to 2C

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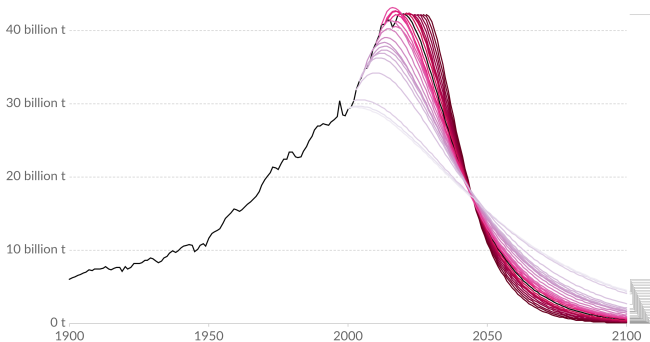
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## CO<sub>2</sub> reductions needed to keep global temperature rise below 2°C

Annual emissions of carbon dioxide under various mitigation scenarios to keep global average temperature rise below 2°C. Scenarios are based on the CO<sub>2</sub> reductions necessary if mitigation had started – with global emissions peaking and quickly reducing – in the given year.

Our World  
in Data



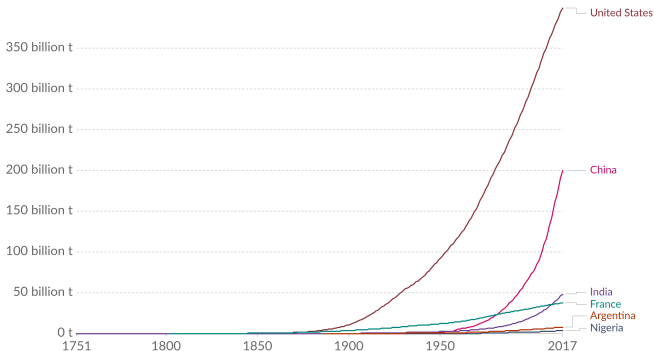
Source: Robbie Andrews (2019); based on Global Carbon Project & IPCC SR15

Note: Carbon budgets are based on a >66% chance of staying below 2°C from the IPCC's SR15 Report.  
[OurWorldInData.org/co2-and-other-greenhouse-gas-emissions](https://OurWorldInData.org/co2-and-other-greenhouse-gas-emissions) • CC BY

- We need to rapidly reduce emissions to zero.

## Cumulative CO<sub>2</sub> emissions

Cumulative carbon dioxide (CO<sub>2</sub>) emissions represents the total sum of CO<sub>2</sub> emissions produced from fossil fuels and cement since 1751, and is measured in tonnes. This measures CO<sub>2</sub> emissions from fossil fuels and cement production only - land use change is not included.



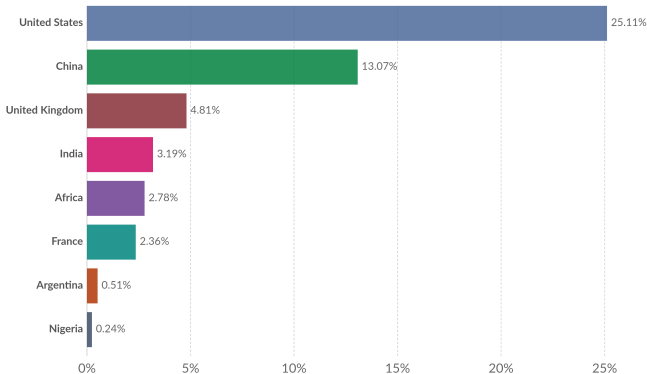
Source: Global Carbon Project (GCP); Carbon Dioxide Information Analysis Centre (CDIAC)  
[OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/](https://OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/) • CC BY

- Emissions are cumulative.
- So total historical emissions are relevant, not just present emissions.



## Share of global cumulative CO<sub>2</sub> emissions, 2018

Each country or region's share of cumulative global carbon dioxide (CO<sub>2</sub>) emissions. Cumulative emissions are calculated as the sum of annual emissions from 1751 to a given year.



Source: OWID based on CDIAC & Global Carbon Project (GCP)

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- Global North has emitted much more than the global south

# A Map of the World

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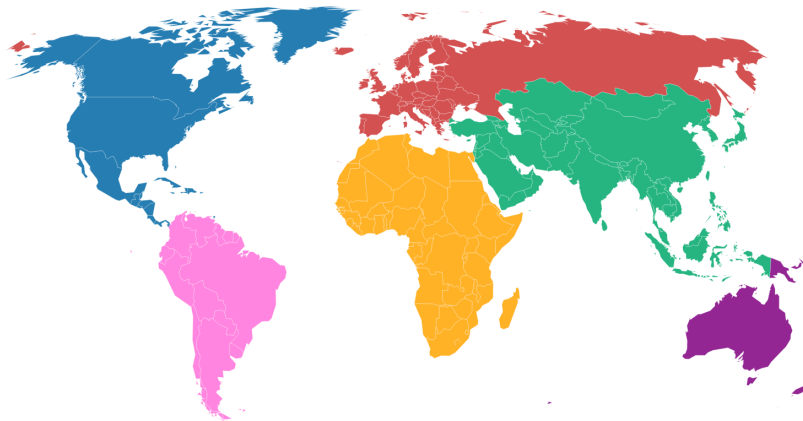
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• <http://www.carbonmap.org>

# Map Weighted by Current Emissions

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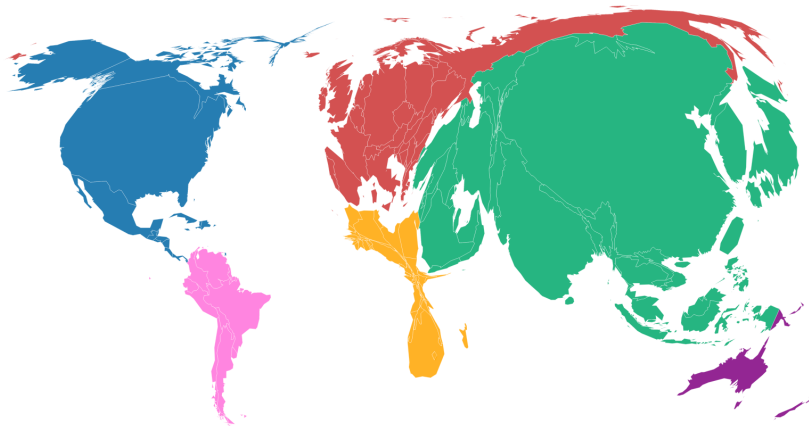
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- <http://www.carbonmap.org>

# Map Weighted by Total Historical Emissions

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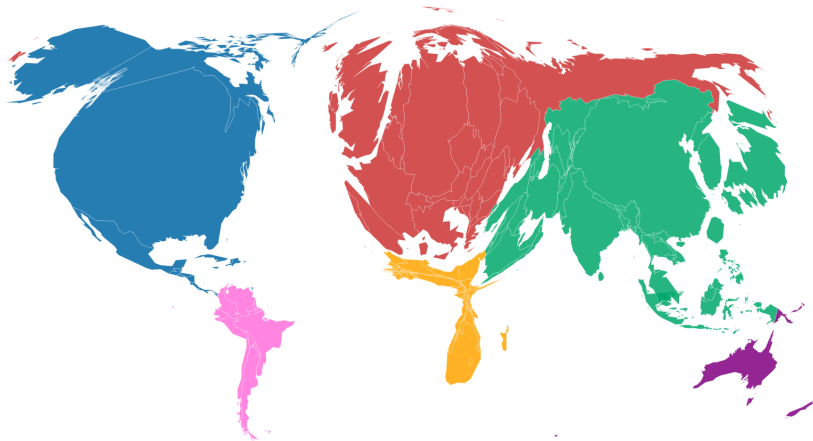
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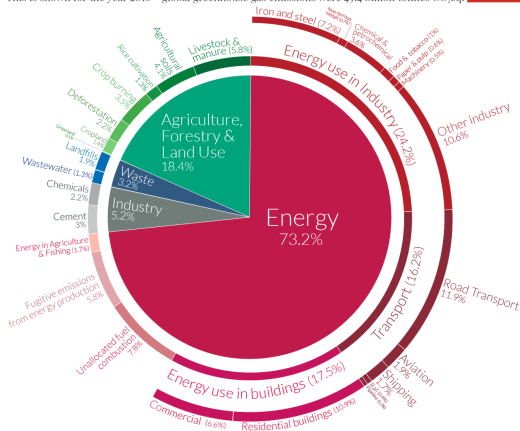
- <http://www.carbonmap.org>

# The Climate Problem is an Energy Problem

## Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO<sub>2</sub>eq.

Our World  
in Data



OurWorldinData.org – Research and data to make progress against the world's largest problems.

Source: Climate Watch, the World Resources Institute [2020].

Licensed under CC-BY by the author Hannah Ritchie (2020).

- About 3/4 of emissions due to energy use.

# Energy is Associated with Prosperity

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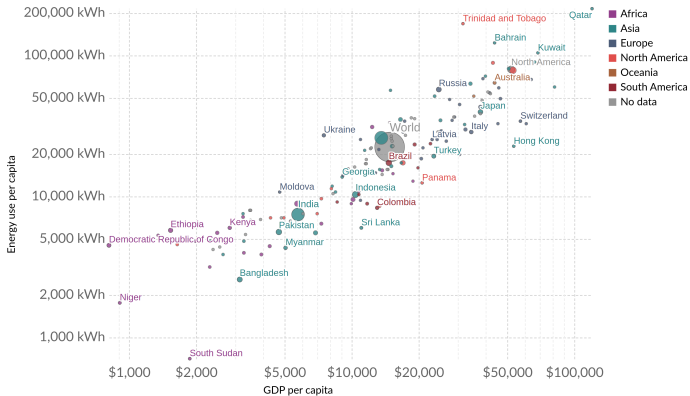
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## GDP per capita vs. Energy use, 2015

Annual energy use per capita, measured in kilowatt-hours per person vs. gross domestic product (GDP) per capita, measured as 2011 international- $\$$ .

Our World  
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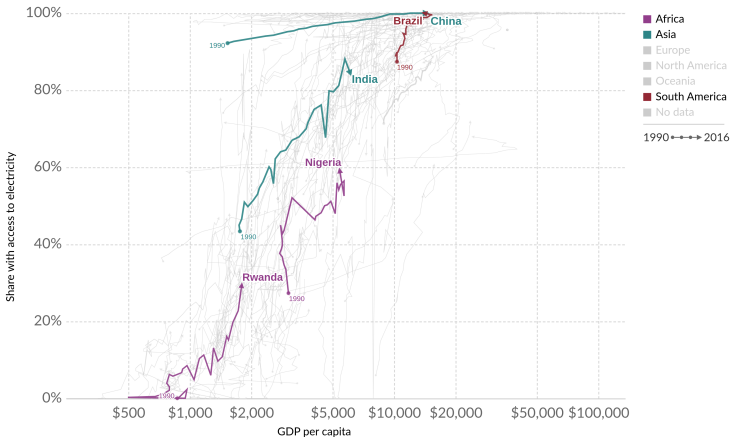
Source: International Energy Agency (IEA) via The World Bank

OurWorldInData.org/energy-production-and-changing-energy-sources/ • CC BY

- Note the logarithmic axes

## Access to electricity vs. GDP per capita, 1990 to 2016

GDP per capita is adjusted for price differences between countries and inflation and measured in international-\$.



Source: The World Bank - World Development Indicators (WDI)

OurWorldInData.org/energy-access • CC BY

- Effects of GHG emissions are cumulative.
- Different countries emit at different rates.
- Vast difference between North and South emissions.
- The climate problem is mostly (75%) an energy problem.
- Need to move to carbon-free energy system



- For relatability, keep numbers between 1 and 1000
- Some key numbers:
  - World Emissions 6 tons CO<sub>2</sub>e/p/year
  - US Emissions 18 tons CO<sub>2</sub>e/p/year
  - Average US electricity: 1 lb CO<sub>2</sub>/kWh
  - US Energy Use: 235 kWh/p/day
- Important to visualize data in different ways

- [www.climatewatchdata.org/ghg-emissions](http://www.climatewatchdata.org/ghg-emissions)
- [ourworldindata.org/co2-and-other-greenhouse-gas-emissions](http://ourworldindata.org/co2-and-other-greenhouse-gas-emissions)
- <https://ourworldindata.org/energy>
- [www.carbonmap.org](http://www.carbonmap.org)
- <https://flowcharts.llnl.gov/>