# Global Electric Power Sector: Engaging with Environmental Issues

IEEE PES Uruguay, Chile, Argentina Chapters
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**INVITED TALK**


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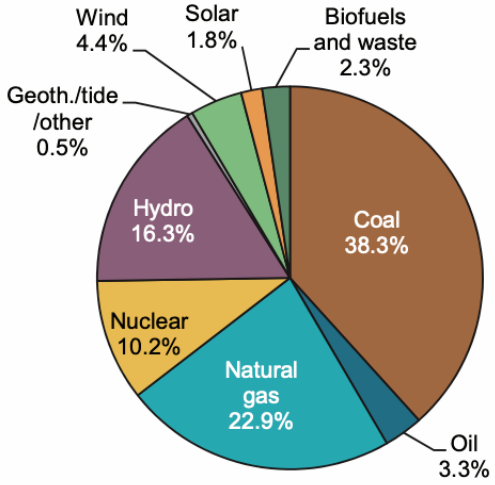
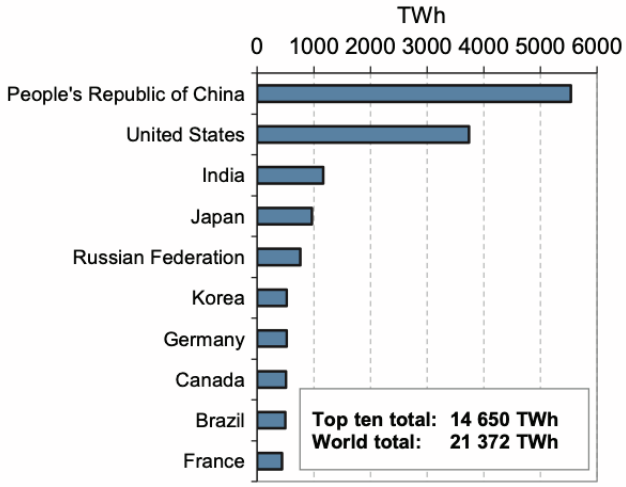
## World Gross Electricity Production in 2017 by Source 25,721 TWh




Source: IEA Electricity Information Overview 2019

## Top 10 Electricity Consuming Countries in 2017 TWh




Source: IEA Electricity Information Overview 2019

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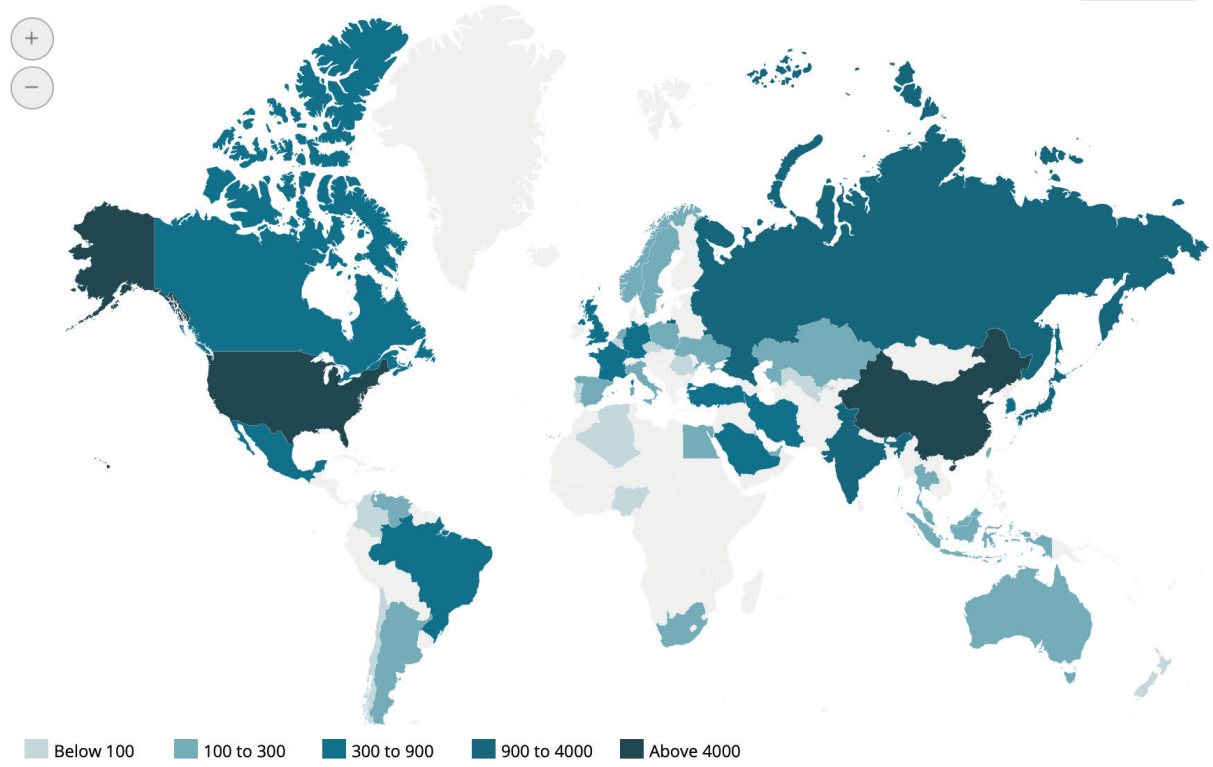
# Top Electricity Producers in 2018 (TWh)




Unit: TWh

Highest

| | |
|---|---|
| China | 7,092 |
| United States | 4,429 |
| India | 1,643 |
| Russia | 1,128 |
| Japan | 1,102 |
| Canada | 663 |
| Germany | 647 |
| Brazil | 596 |
| South Korea | 593 |
| France | 571 |
| Saudi Arabia | 351 |
| United Kingdom | 334 |

Source: Enerdata Global Energy Statistical Yearbook 2019
https://yearbook.enerdata.net/electricity/world-electricity-production-statistics.html

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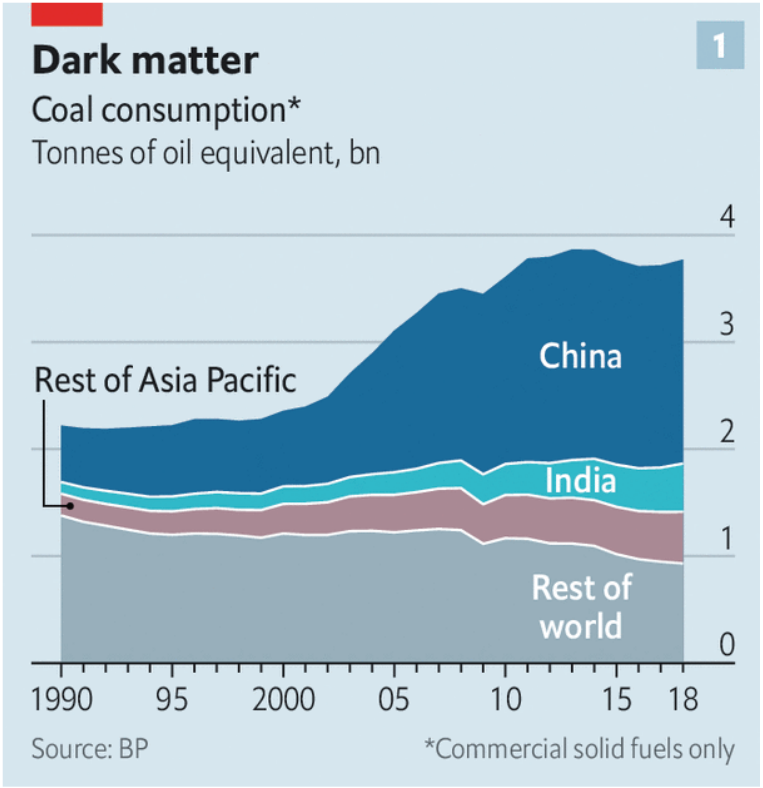
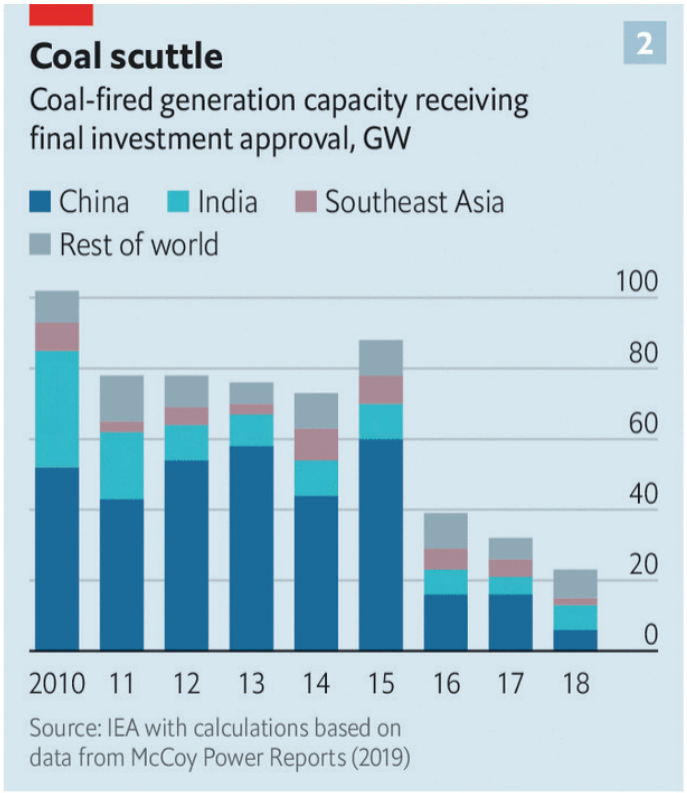
# Over 75% of Global Demand for Coal Comes from Asia




The Economist

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## Top 20 Countries that emitted the most CO2 in 2016

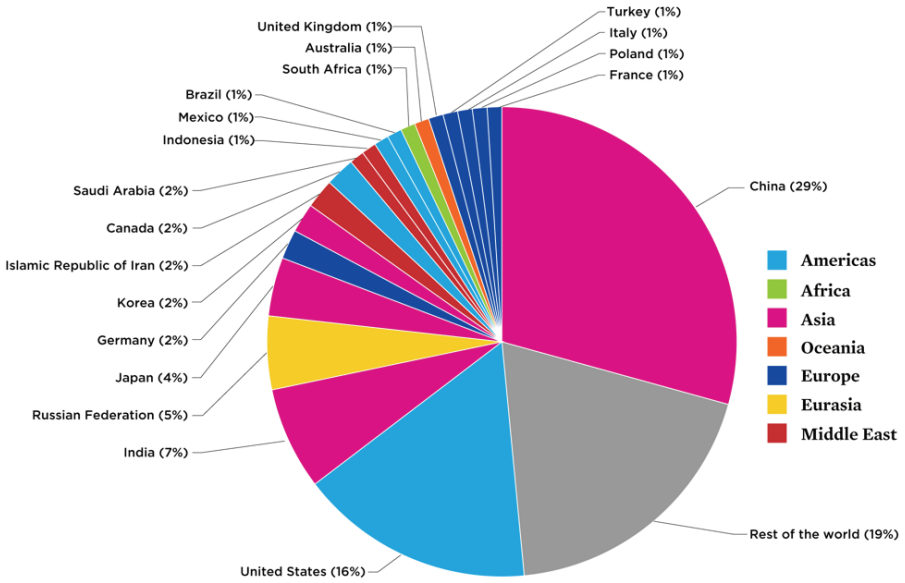
| Rank | Country | $CO_2$ emissions (total) |
|---|---|---|
| 1 | China | 9056.8MT |
| 2 | United States | 4833.1MT |
| 3 | India | 2076.8MT |
| 4 | Russian Federation | 1438.6MT |
| 5 | Japan | 1147.1MT |
| 6 | Germany | 731.6MT |
| 7 | South Korea | 589.2MT |
| 8 | Islamic Republic of Iran | 563.4MT |
| 9 | Canada | 540.8MT |
| 10 | Saudi Arabia | 527.2MT |
| 11 | Indonesia | 454.9MT |
| 12 | Mexico | 445.5MT |
| 13 | Brazil | 416.7MT |
| 14 | South Africa | 414.4MT |
| 15 | Australia | 392.4MT |
| 16 | United Kingdom | 371.1MT |
| 17 | Turkey | 338.8MT |
| 18 | Italy | 325.7MT |
| 19 | Poland | 293.1MT |
| 20 | France | 292.9MT |

REPORTS & MULTIMEDIA / EXPLAINER

# Each Country's Share of CO2 Emissions

Published Jul 16, 2008 | Updated Oct 10, 2019

More:
En español




© 2019 Union of Concerned Scientists

Source: Union of Concerened Scientists https://www.ucsusa.org/resources/each-countrys-share-co2-emissions

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## Ranking by per capita CO2 emissions 2016

| Rank | Country | $CO_2$ emissions (per capita) |
|---|---|---|
| 1 | Saudi Arabia | 16.3T |
| 2 | Australia | 16.2T |
| 3 | United States | 15.0T |
| 4 | Canada | 14.9T |
| 5 | South Korea | 11.6T |
| 6 | Russian Federation | 9.9T |
| 7 | Japan | 9.0T |
| 8 | Germany | 8.9T |
| 9 | Poland | 7.7T |
| 10 | South Africa | 7.4T |
| 11 | Islamic Republic of Iran | 7.1T |
| 12 | China | 6.4T |
| 13 | United Kingdom | 5.6T |
| 14 | Italy | 5.4T |
| 15 | France | 4.5T |
| 16 | Turkey | 4.2T |
| 17 | Mexico | 3.6T |
| 18 | Brazil | 2.0T |
| 19 | Indonesia | 1.7T |
| 20 | India | 1.6T |

Source: Union of Concerened Scientists https://www.ucsusa.org/resources/each-countrys-share-co2-emissions

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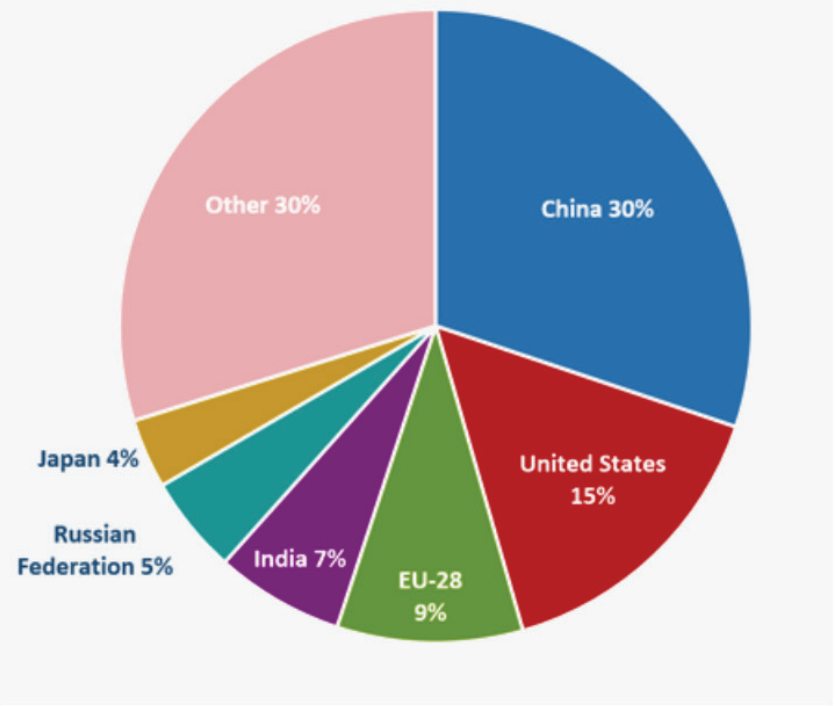
## 2014 Global $CO_2$ Emissions from Fossil Fuel Combustion and Some Industrial Processes




Source: Boden, T.A., Marland, G., and Andres, R.J. (2017). National CO2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751-2014, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, doi 10.3334/CDIAC/00001_V2017.

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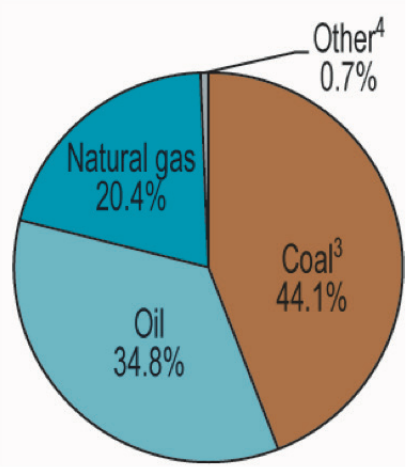
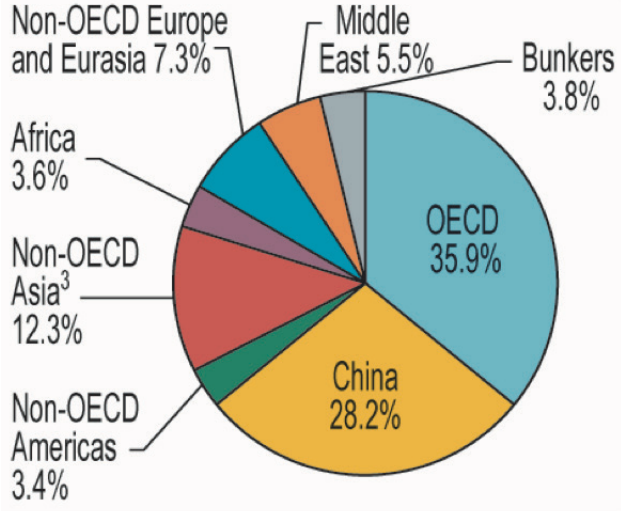
Global $CO_2$ Emissions from Fuel Combustion by Fuel Type - 2016




32 316 Mt of $CO_2$

Global $CO_2$ Emissions from Fuel Combustion By Region - 2016




32 316 Mt of $CO_2$

Source: IEA Key World Energy Statistics 2018

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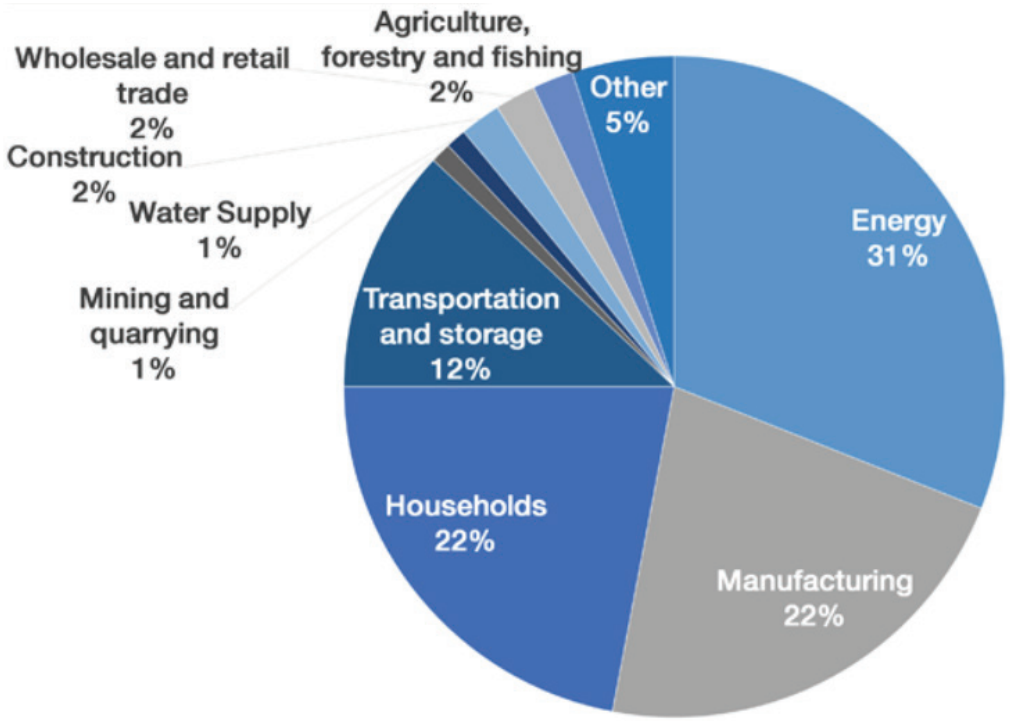
# Sources of CO2 Emissions in Europe 2015




Source: OECD Environmental Statistics

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# Changes in Generation Mix in China

| Year | Hydro/Solar/Wind (%) | Thermal (%) |
|---|---|---|
| 2001 | 25.56 | 73.47 |
| 2016 | 33.80 | 63.77 |
| 2018 | 37.00 | 60.00 |
| 2030 | 52.00 | 42.00 |

China will start to reduce its CO2 emissions beginning in 2030



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# Anthropogenic Carbon Emissions (2000)

- Electric Power Plants (33%)
- Transportation (33%)
- Direct Industrial Use (20%)
- Residential & Commercial Use (12%)



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# Six Greenhouse Gases

Carbon dioxide ($CO_2$)

Methane ($CH_4$)

Nitrous oxide ($N_2O$)

Hydro fluorocarbons (HFCs)

Per fluorocarbons (PFCs)

Sulphur hexafluoride ($SF_6$)

1997 CO2 emissions from fossil fuels and cement production: 30.4 billion tons

2018 CO2 emissions from fossil fuels and cement production: 41.1 billion tons



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# Global Warming Potential (GWP) of Greenhouse Gases

| | |
|---|---|
| Carbon dioxide ($CO_2$): | 1 |
| Methane ($CH_4$): | 28 |
| Nitrous oxide ($N_2O$): | 265 |
| Hydro fluorocarbons (HFCs): | 138 |
| Per fluorocarbons (PFCs): | 6,630 |
| Sulphur hexafluoride ($SF_6$): | 23,500 |

*(over 100-year time scale)*



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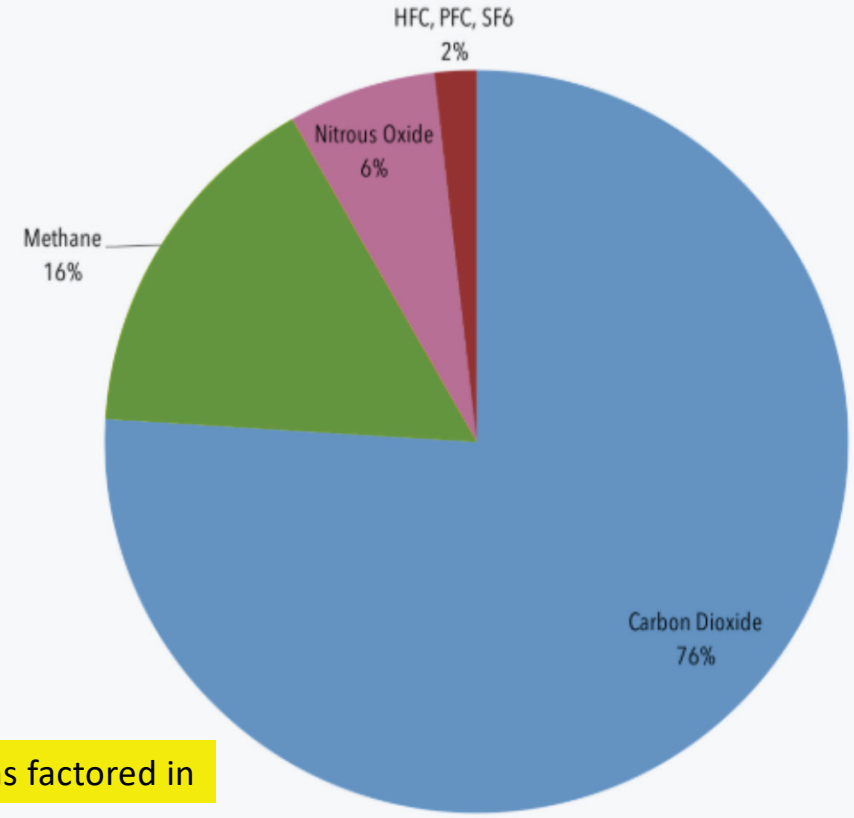
## Global Manmade Greenhouse Gas Emissions by Gas, 2015




Concentrations factored in



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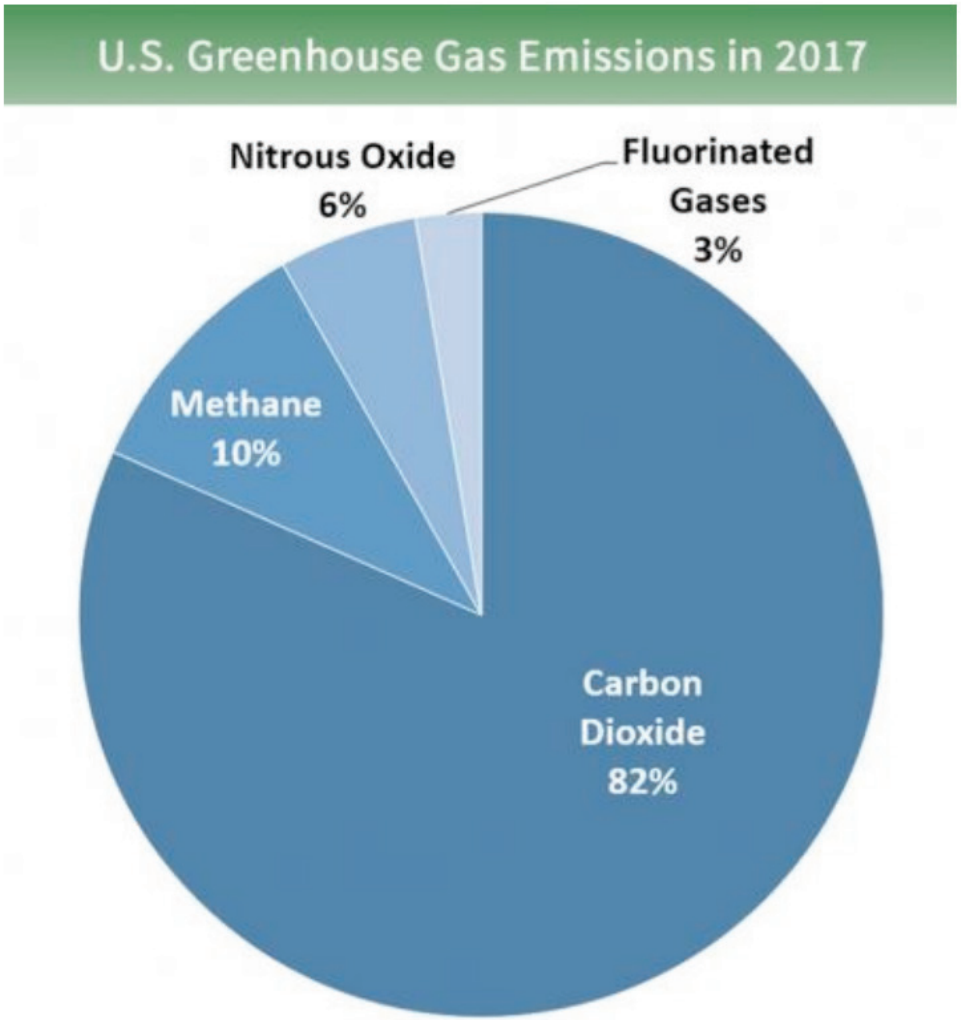




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# Sources of atmospheric methane

(1) Natural wetlands;

(2) Paddy rice fields;

(3) Emission from livestock production systems;

(4) Biomass burning (including forest fires);

(5) Anaerobic decomposition of organic waste in landfills;

(6) Fossil methane emission during the exploration and transport of fossil fuels.



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# Emission Characteristics of Power Plants in the US (grams/kWhr)

| Plant Type | NOx | $SO_2$ | $CO_2$ |
|---|---|---|---|
| Gas | 2.32 | 0.004 | 490 |
| Oil | 2.02 | 5.08 | 781 |
| Coal | 3.54 | 9.26 | 1090 |



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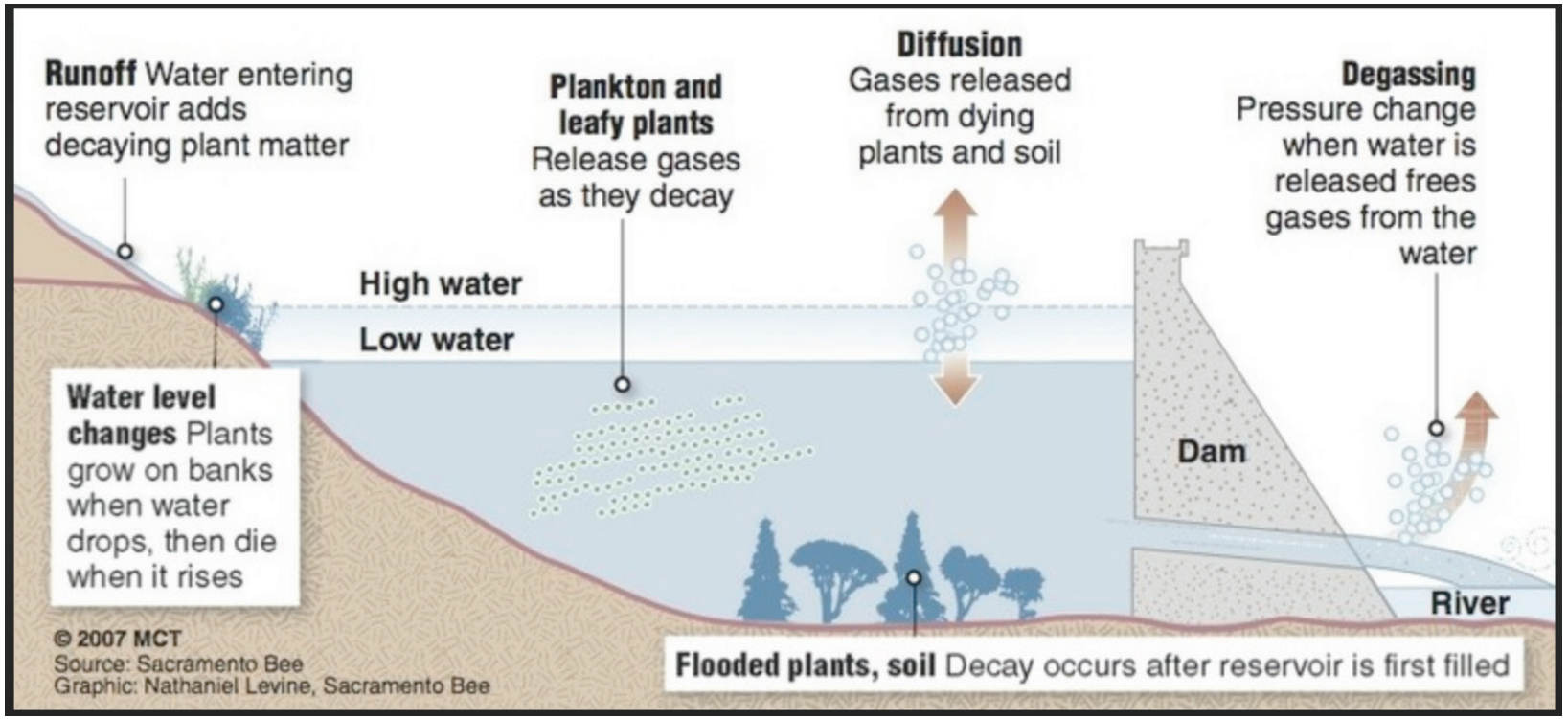
# Greenhouse Gases from Hydroelectricity

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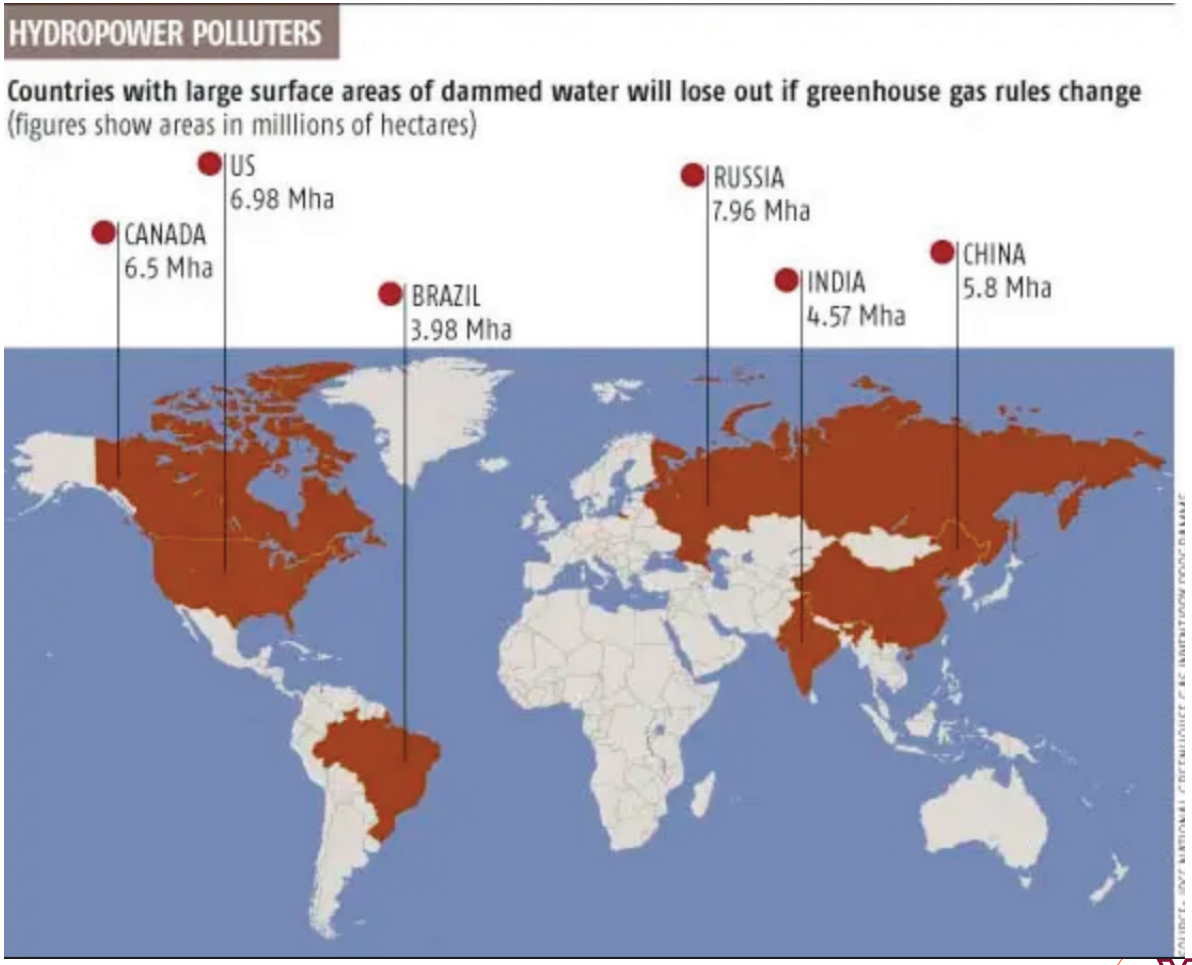




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# Hydroelectricity is not Emission Free

One kWhr of coal-based electricity releases 1090 gm of $CO_2$

One kWhr of hydro-based electricity releases 225 gm of $CO_2$ equivalent

One litre of gasoline releases 3.00 kg of $CO_2$ from manufacture to consumption in a vehicle



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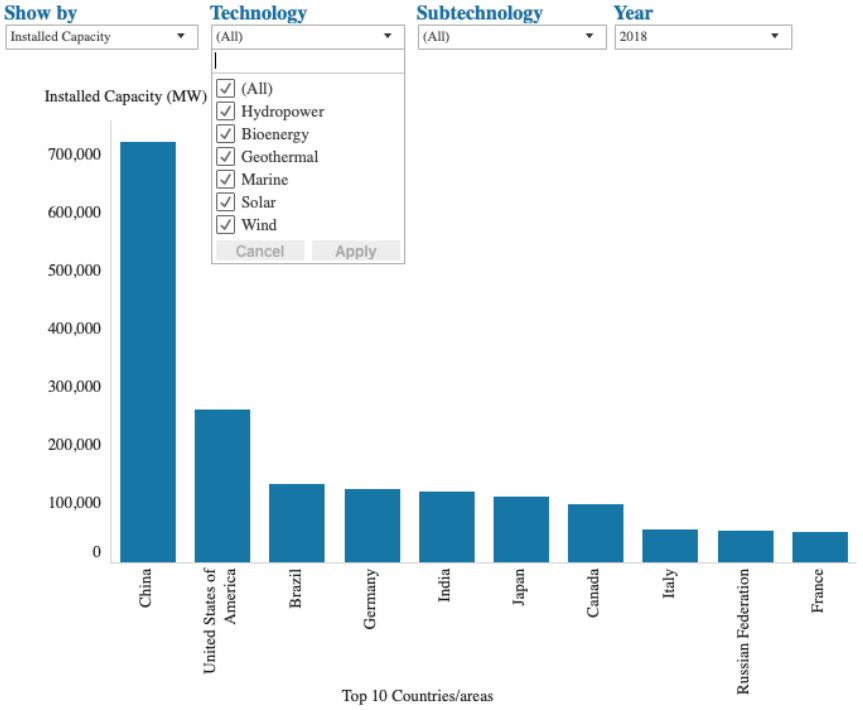
# Reduce Carbon Emissions from Electricity Production

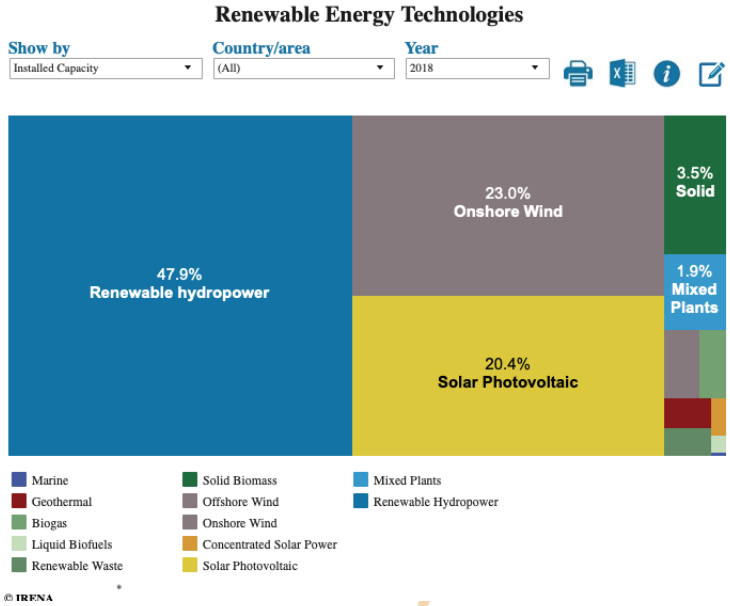
(1) Use less electricity

(2) Use less fuel to produce electricity

(3) Produce more electricity from renewables & nuclear

# Top Ten Countries Total Installed Renewable Energy Capacity in 2018




Source: International Renewable Energy Agency IRENA https://www.irena.org/Statistics/

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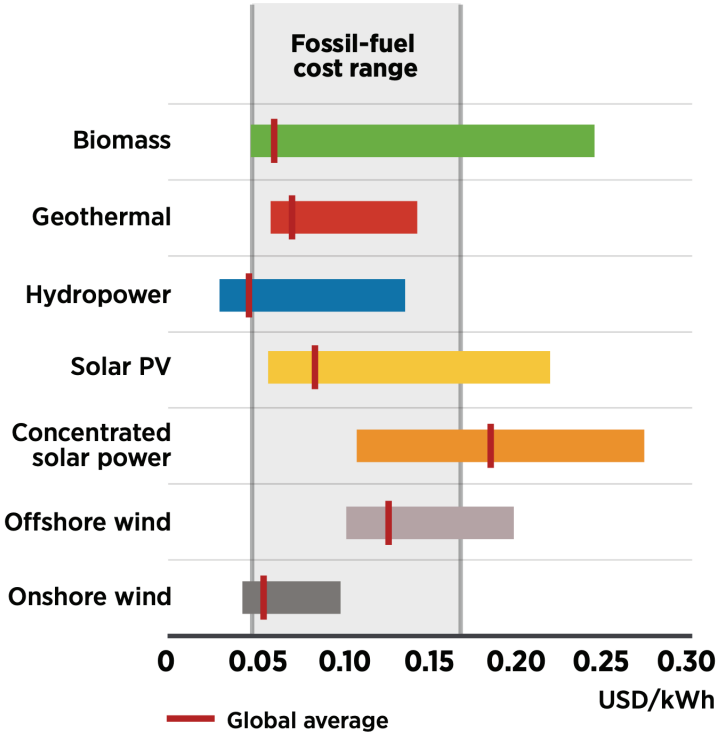
## Renewable power generation has reached a competitive tipping point




» Renewable power generation costs in 2018

Source: People, Planet and Prosperity: Raising Climate Ambitions Through Renewables, IRENA 2019

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# So, What is the bottom line?

- Efforts in the electric power sector by replacing fossil fuel with renewables and nuclear will help
- But if emission from the transportation sector continues to rise, the power sector contributions will not be enough
- Large scale Electric Vehicle deployment will help, but question remains – how will the EV be powered

# I would like to see a broader IEEE

We need to ensure that we are “READY FOR RECOVERY”, when we get back to the “NEW NORMAL” after COVID-19. Let us enhance cooperation, collaboration and community spirit.

For this we need to make IEEE broader so that IEEE is more relevant to the work our members do regardless where they work.

We need more participation from volunteers globally in IEEE governance. A broader based IEEE will make the Institute more relevant to technologists and academics from all parts of the world.

I would like to see more IEEE Senior Members and IEEE Fellows from Regions 8, 9 & 10



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## Prof. Saifur Rahman (s.rahman@ieee.org)

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Past-Chair, IEEE Publication Services & Products Board

PES accomplishments:

- PES University
- PES Corporate Engagement Program
- PES Chapters' Councils in China, India, Africa and Latin America

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