

# Sustainable Development and Low Emissions Economies

## Introduction to Sustainable Development and Green Innovation

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May 2025



*We can go for a walk where it's quiet and dry  
And talk about precious things  
Like love and law and poverty, ooh-oo  
(These are the things that kill me)  
We can go for a walk where it's quiet and dry  
And talk about precious things  
But the rain that flattens my hair, ooh  
(These are the things that kill me)*

The Smiths - [The Queen is dead \(1986\)](#)

# Websites-Podcasts I

- Οικονομικός Ταχυδρόμος
- Energy Press
- The Guardian - Environment
- Our World in Data  
Accesible Data and Visualizations
- Bruegel  
Top EU Think Tank
- The Intergovernmental Panel on Climate Change (IPCC)
- European Environmental Agency
- Climate Adapt  
EU Knowledge Repository on Climate Adaptation

## Websites-Podcasts II

- [UN SDSN](#)  
The United Nations Sustainable Development Solutions Network
- [Freakonomics Radio](#)  
Podcast about the hidden side of Economic Thought
- [Climate Rising](#)  
Harvard Business School Podcast
- [Climate Solutions](#)  
EIB Podcast



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- Assessing Policy Initiatives for Net Zero in terms of Efficiency and Justice
- Evaluating the Sustainability Performance of Economic and Social Pillars
- Thinking as Economists!

# Economics Buzzwords

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- Data

- ▶ Key tool for *Evidence-based Policy*

# Incentives everywhere

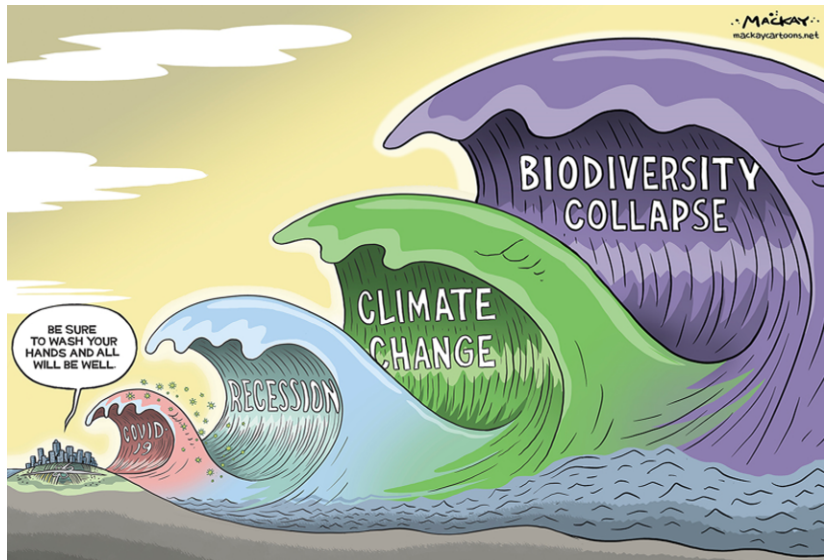
- *Nobel Laureate* R. Thaler  
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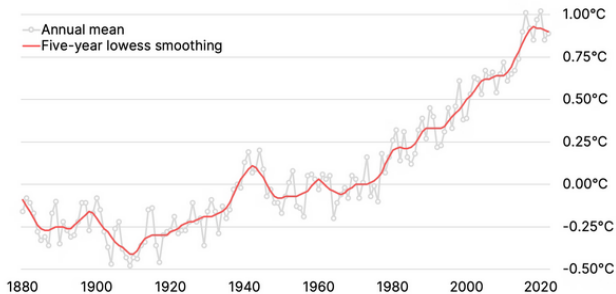
# Poly-Crisis



# Global Temperature on the Rise

## Temperatures have risen 1°C

Temperatures are one degree Celsius above the long-term average



January 2023

Source:  
NASA

Note:  
Land-ocean  
temperature  
index  
(base period  
1951-80)



NAT BULLARD

# Economic Inequality

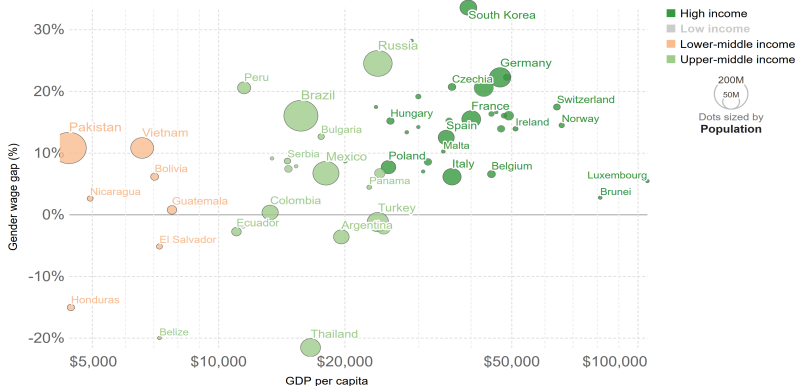


# Gender Inequality

## Gender wage gap vs GDP per capita, 2016

Our World  
in Data

The vertical axis shows the unadjusted gender wage gap calculated as the difference between average earnings of men and average earnings of women expressed as a percentage of average earnings of men. The horizontal axis shows GDP per capita, after adjusting for differences in price levels across countries.

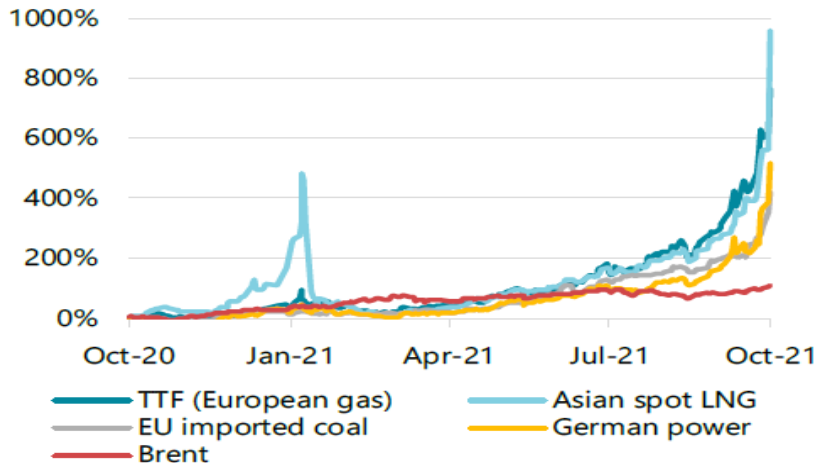


Source: ILOSTAT, Data compiled from multiple sources by World Bank

OurWorldInData.org/income-inequality • CC BY

# Energy Crisis

## Evolution of Energy Prices, 2020-2021





# Cost of Living Crisis



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  - ▶ **International Cooperation** for the achievement of these Goals

# Sustainable Development Goals





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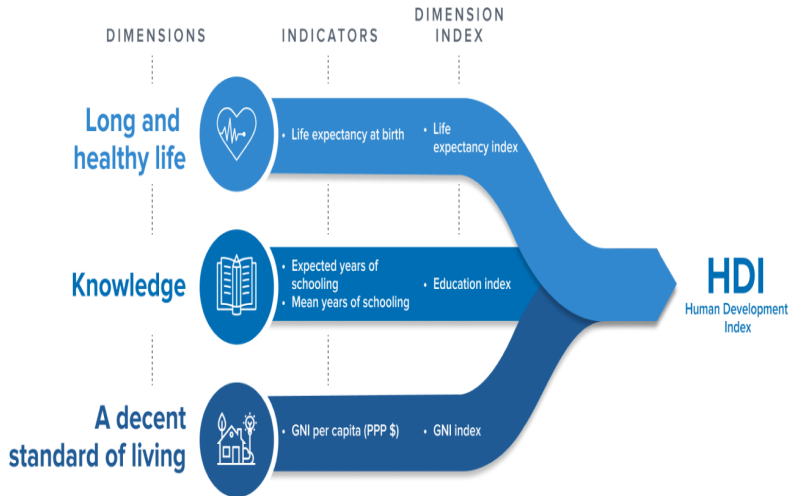
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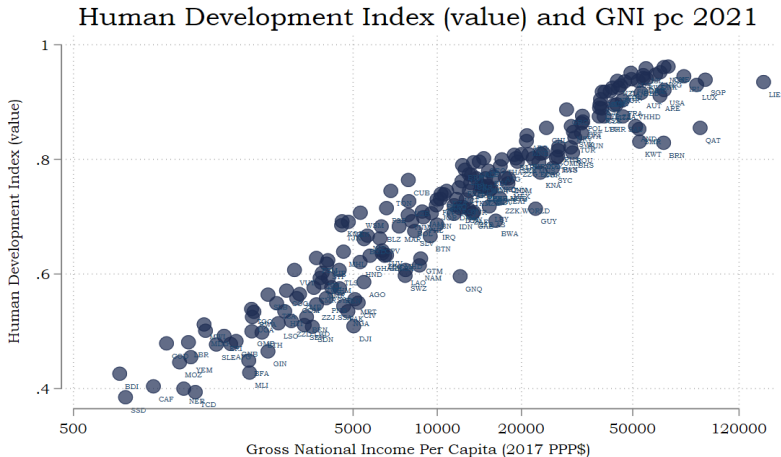
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- Associated with but *not Synonymous to Economic Growth*

# Human Development Index Dimensions



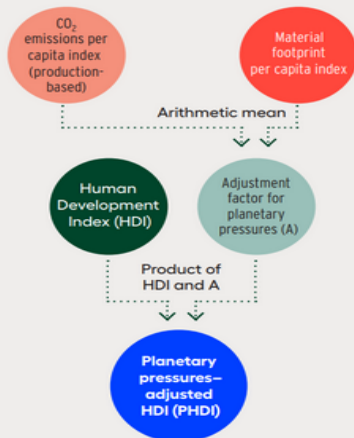
# Human vs(?) Economic Development



Source: UNDP

# Planetary Pressures Adjusted HDI

**PHDI is created by multiplying the HDI by an adjustment factor**



**Relationship among HDI, A and PHDI**

**HIGHER PLANETARY PRESSURES**

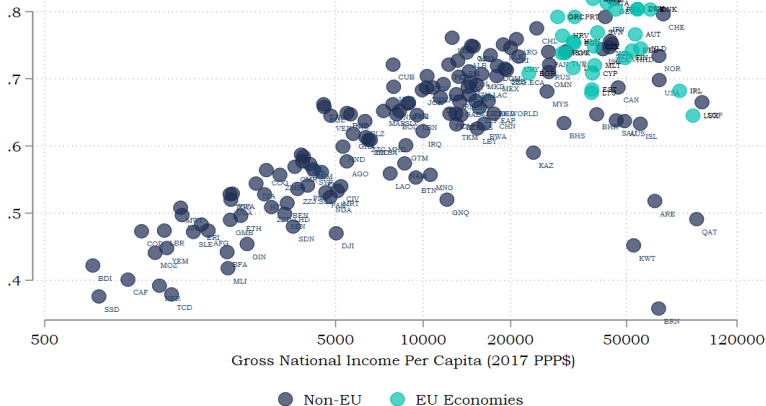
0.000 PHDI = 0





# Accounting for Planetary Pressures

Planetary pressures-adjusted HDI and GNI pc 2021



Source: UNDP

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  - ▶ Food (In)Security
  - ▶ Climate Migration
  - ▶ Fiscal Burden

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- Global mean sea level increased by 0.2 m between 1901 and 2018.

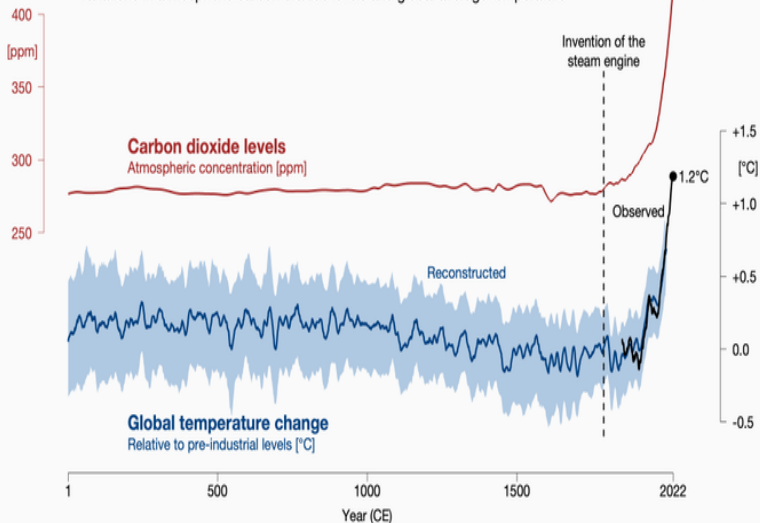
# IPCC SIXTH ASSESSMENT REPORT (AR6)

*Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850–1900 in 2011–2020. Global greenhouse gas emissions have continued to increase, with unequal historical and ongoing contributions arising from unsustainable energy use, land use and land-use change, lifestyles and patterns of consumption and production across regions, between and within countries, and among individuals (high confidence)*

# Human-Induced Climate Change

## Observed changes in climate over the last 222 years

Variations in atmospheric carbon dioxide levels and global average temperature

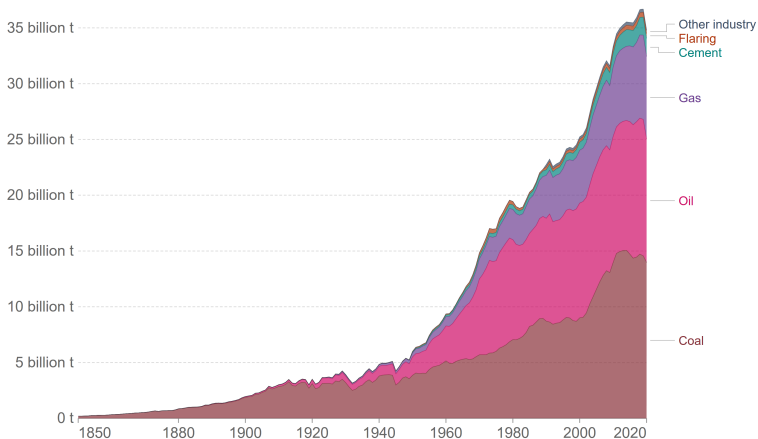


# CO<sub>2</sub> Emissions by fuel

## CO<sub>2</sub> emissions by fuel type, World

Annual carbon dioxide (CO<sub>2</sub>) emissions from different fuel types, measured in tonnes per year.

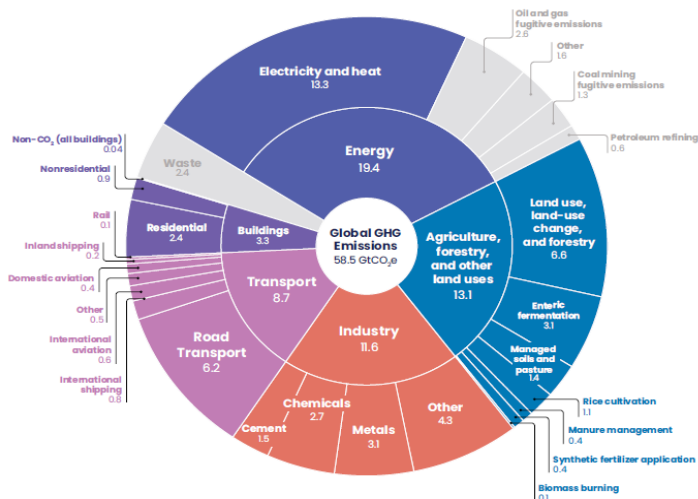
Our World  
in Data



Source: Global Carbon Project

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY

# CO<sub>2</sub> Emissions by Sector

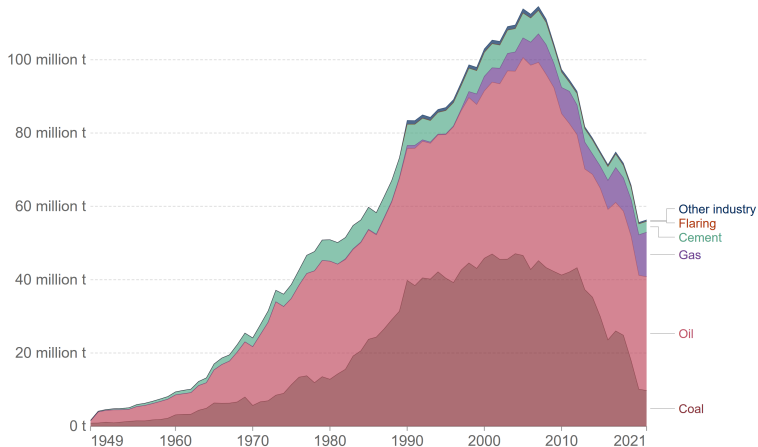


Notes: CO<sub>2</sub> = carbon dioxide; GHG = greenhouse gas; GtCO<sub>2</sub>e = gigatonnes of carbon dioxide equivalent.

Source: Minx et al. (2022), described in Minx et al. (2021) and used in IPCC (2022b).

# Greece CO2 Emissions by Source

CO2 emissions by fuel or industry type, Greece



Source: Our World in Data based on the Global Carbon Project (2022)

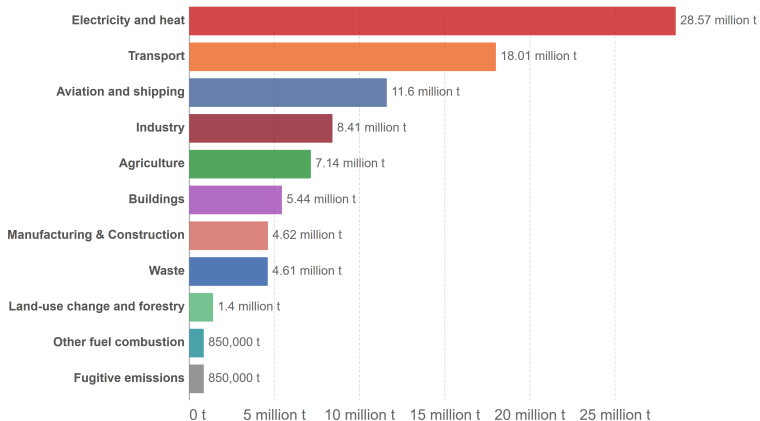
[OurWorldInData.org/co2-and-greenhouse-gas-emissions](https://OurWorldInData.org/co2-and-greenhouse-gas-emissions) • CC BY



# Greece CO2 Emissions by Sector

## Greenhouse gas emissions by sector, Greece, 2019

Emissions are measured in carbon dioxide equivalents (CO2eq). This means non-CO2 gases are weighted by the amount of warming they cause over a 100-year timescale.



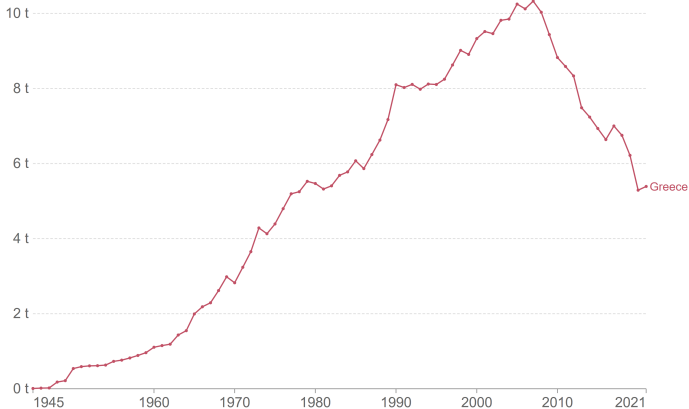
Source: Our World in Data based on Climate Analysis Indicators Tool (CAIT). [OurWorldInData.org/co2-and-greenhouse-gas-emissions](https://OurWorldInData.org/co2-and-greenhouse-gas-emissions) • CC BY

# Greece CO2 per capita

## Per capita CO<sub>2</sub> emissions

Carbon dioxide (CO<sub>2</sub>) emissions from fossil fuels and industry<sup>1</sup>. Land use change is not included.

Our World  
in Data



Source: Our World in Data based on the Global Carbon Project (2022)

OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

**1. Fossil emissions:** Fossil emissions measure the quantity of carbon dioxide (CO<sub>2</sub>) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO<sub>2</sub> includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

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- ▶ Prevent & Adapt to *Extreme Events* (floods, droughts, wildfires)
- ▶ *Compensate* populations severely affected by CC

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- **Behavioral Change**

Societal Shift towards Sustainable Practices

# Climate Policies and Temperature

## Global greenhouse gas emissions and warming scenarios



- Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
- Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.

Annual global greenhouse gas emissions  
in gigatonnes of carbon dioxide-equivalents

150 Gt

100 Gt

50 Gt

Greenhouse gas emissions  
up to the present

0

1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

**No climate policies**  
4.1 – 4.8 °C

→ expected emissions in a baseline scenario if countries had not implemented climate reduction policies.

**Current policies**  
2.5 – 2.9 °C

→ emissions with current climate policies in place result in warming of 2.5 to 2.9°C by 2100.

**Pledges & targets (2.1 °C)**  
→ emissions if all countries delivered on reduction pledges result in warming of 2.1°C by 2100.

**2°C pathways**  
**1.5°C pathways**

Data source: Climate Action Tracker (based on national policies and pledges as of November 2021).  
[OurWorldinData.org](https://ourworldindata.org) – Research and data to make progress against the world's largest problems.

Last updated: April 2022.  
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# Global Temperature Impacts

## POTENTIAL IMPACTS OF CLIMATE CHANGE

°C above pre-industrial levels

1.5°C

- Major effects on warm water coral reef ecosystem.
- Significant impacts on vulnerable ecosystems and species (polar regions, wetlands, and cloud forests).
- Increase in coastal and river flooding.
- Increase in extreme weather events.
- Increase in the spread of tropical infectious disease.
- Increase in heat-related morbidity and mortality.

2°-3°C

- The Maldives, the Marshall Islands, Tuvalu, and many other small island nations have been abandoned.
- Major loss of warm water coral reef ecosystem.
- Major changes in the Arctic regions with a substantial loss of Arctic sea-ice.
- Major increase in extreme weather events and the spread of infectious disease.
- Major increase in heat related morbidity and mortality, especially in the low latitudes.
- Significant impacts on vulnerable ecosystems (polar regions, wetlands, cloud forests, and mangroves).
- Significant increase in coastal and river flooding around the world.
- Significant impacts on low latitude fisheries.
- Decrease in crop yields and productivity especially in the tropics and sub-tropical regions.

3°-4°C

- Major impacts on all ecosystems including significant increase in species extinctions.
- Loss of all warm water and many coldwater coral reef ecosystems.
- Arctic completely free of sea ice in summer, Arctic temperature increase by 8°C.
- Majority of mountain glaciers have disappeared, including all ice on Kilimanjaro (Tanzania).
- Major increase in extreme weather events and spread of infectious disease.
- Major decreases in agricultural and fishery production and available water resources.
- Food and water security become major political and humanitarian issues.
- Environmental forced mass migration increases.
- Ocean and terrestrial carbon sinks reduce accelerating climate change.

4°-5°C

- Catastrophic loss of ecosystems and species all around the world.
- Melting of Western Antarctic/Greenland ice sheets accelerate, causes significant global sea level rises.
- Fifth of world population affected by flooding and major coastal cities are abandoned.
- Environmental forced mass migration accelerates and there is an increase in conflicts over resources.
- In many countries summer temperatures persistently stay above 40°C.
- Heat waves with temperatures as high as 50°C have become common.
- Over 3.5 billion people are now water stressed.
- Wildfires have created major air pollution events and human health crises.
- Global food production plummets, leading to widespread malnutrition and starvation.

5°->6°C

- Do not go there.

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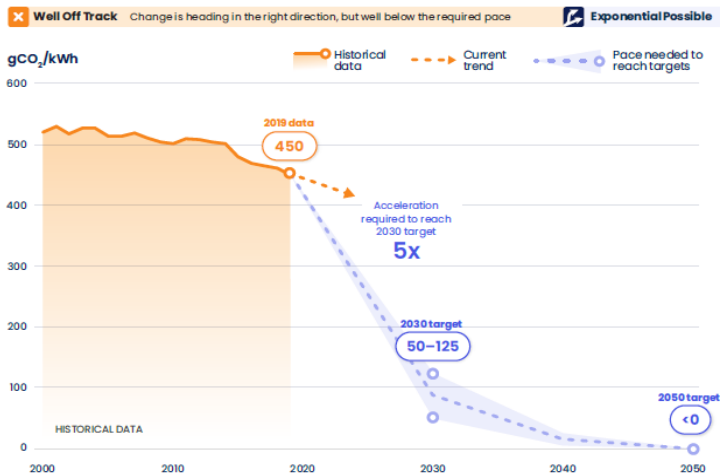
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- **Example:** Clean energy generation + healthy diets from sustainable food systems, + universal health coverage and social protection  
= Substantial **health and well-being co-benefits**

# Energy Efficiency Trends and Needs



Notes: gCO<sub>2</sub>/kWh = grams of carbon dioxide per kilowatt-hour. Data for 2021 are an estimate for now; 2020 data will be added when available.

Sources: Historical data from IEA (2021), computed using the "GHG emissions from fuel combustion" data product in accordance with the associated IEA license agreement; targets from Climate Action Tracker (2020b).

# Innovation Essentials

## Definition

Innovation is defined as a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product innovation) or brought into house by the unit (process Innovation)

OECD Oslo Manual 2018



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- *Under capitalism, innovative activity-which in other types of economy is fortuitous and optional-becomes mandatory, a life and death matter for the firm*

W. Baumol 2002

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- Knowledge as a (quasi) *Public Good* → Low Appropriation of Benefits
  - ▶ G. Flaubert (1911): *All Innovators die in the poor house. Someone else profits from their discoveries, it is not fair.*

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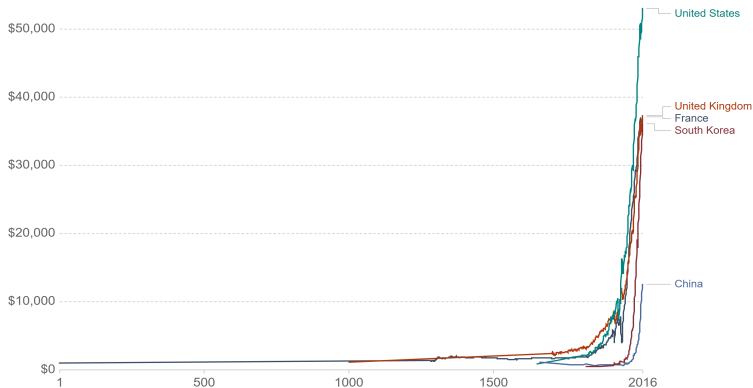
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  - ▶ G. Flaubert (1911): *All Innovators die in the poor house. Someone else profits from their discoveries, it is not fair.*
- **Matt Ridley**: *Innovation is the child of freedom and the parent of prosperity. It is on balance a very good thing. We abandon it at our peril*

# Industrial Revolution and GDP per capita

## GDP per capita, 1 to 2016

GDP per capita adjusted for price changes over time (inflation) and price differences between countries – it is measured in international-\$ in 2011 prices.

Our World  
in Data



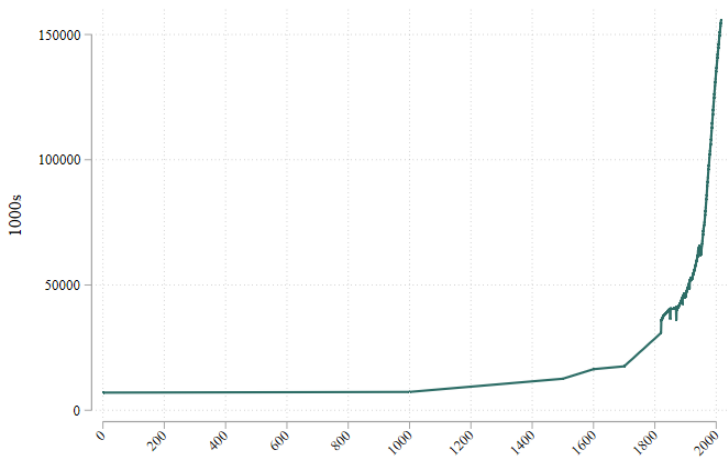
Source: Maddison Project Database (2018)

Note: These series are adjusted for price differences between countries based on only a single benchmark year, in 2011. This makes them suitable for studying the growth of incomes over time but not for comparing income levels between countries.

OurWorldInData.org/economic-growth • CC BY



# World Population

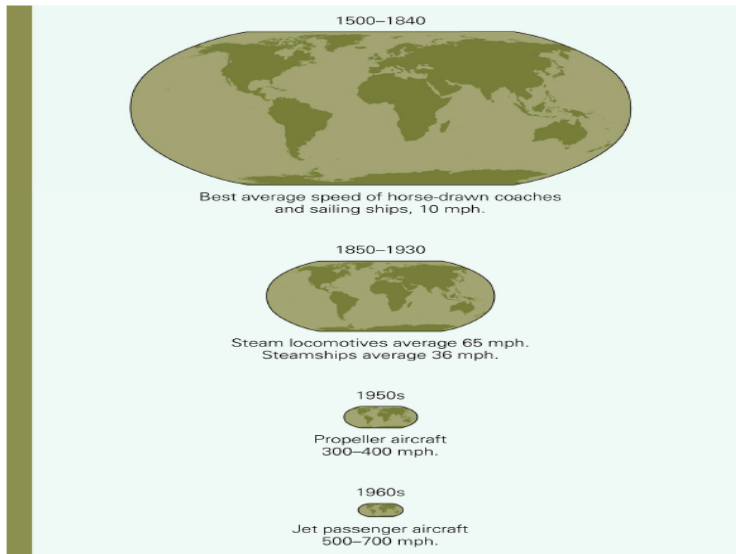


Source: Maddison (2008)

# Embedded Human Knowledge



# The Death of Distance



# Innovation NOT Invention

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- *There is no day when you can say: computers did not exist the day before and did the day after, any more than you could say that one ape-person was an ape, and her daughter was a person*  
(Matt Ridley)



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Steve Ballmer, chief executive of Microsoft 2007

# Innovation and Institutions

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  - ▶ Social Attitudes that promote **Systemic Change** and are open to new Ideas

# Chinese vs Columbus Flagship



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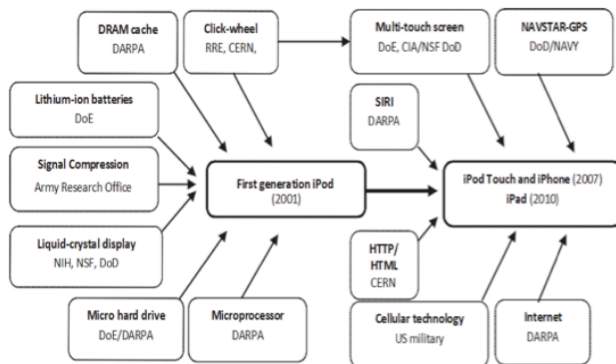
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- Strong Role of Government in US Innovation dominance (DARPA, Bell Labs) and Japanese & Korean tech boom after 1950

# Public Sector and Smart Innovation

## What makes the iPhone so 'smart'?



# Innovation Promotion Toolbox

## Innovation Policy Toolkit

<i>Policy</i>	<i>Quality of evidence (1)</i>	<i>Conclusiveness of evidence (2)</i>	<i>Net benefit (3)</i>	<i>Time frame (4)</i>	<i>Effect on inequality (5)</i>
Direct R&D grants	Medium	Medium	👍👍	Medium run	↑
R&D tax credits	High	High	👍👍👍	Short run	↑
Patent box	Medium	Medium	Negative	NA	↑
Skilled immigration	High	High	👍👍👍	Short to medium run	↓
Universities: incentives	Medium	Low	👍	Medium run	↑
Universities: STEM supply	Medium	Medium	👍👍	Long run	↓
Trade and competition	High	Medium	👍👍👍	Medium run	↑
Intellectual property reform	Medium	Low	Unknown	Medium run	Unknown
Mission-oriented policies	Low	Low	👍	Medium run	Unknown

Source: Bloom, van Reenen and Williams (2019)

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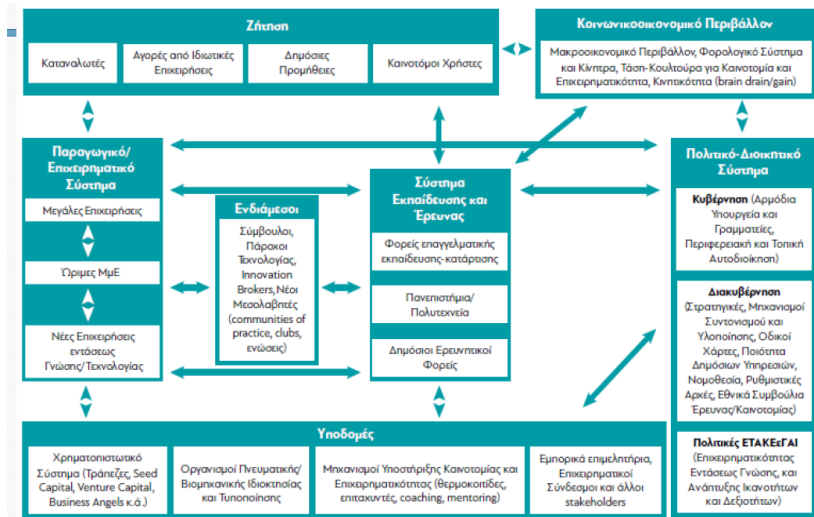
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*Network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies*
- National and Regional Innovation Systems foster *Creation and Dissemination* of Innovation

# National Innovation System (DIANEOSIS)



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- **Tolerance**
  - ▶ Embrace *Different People and New Ideas*
  - ▶ Directly connected with the other 2 T's!

# European Innovation Scoreboard

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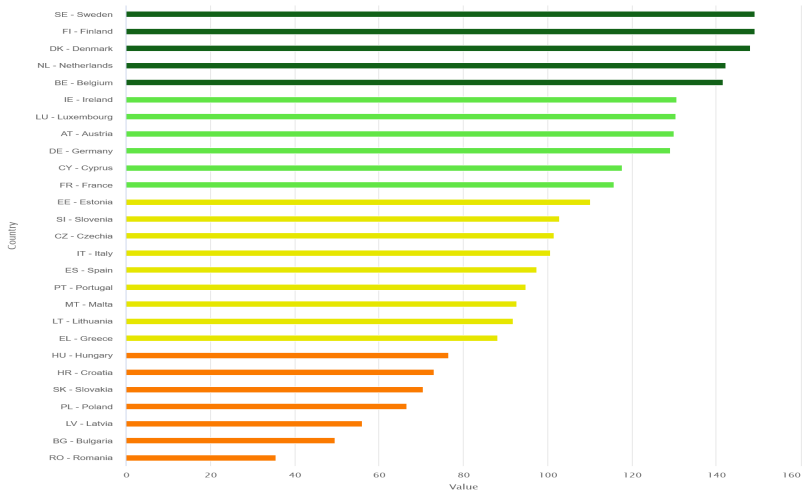
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- Strong in Human Capital and Innovators, lacking in Commercialization, attracting and retaining Talent & Government Support

# EIS - Summary Innovation Index

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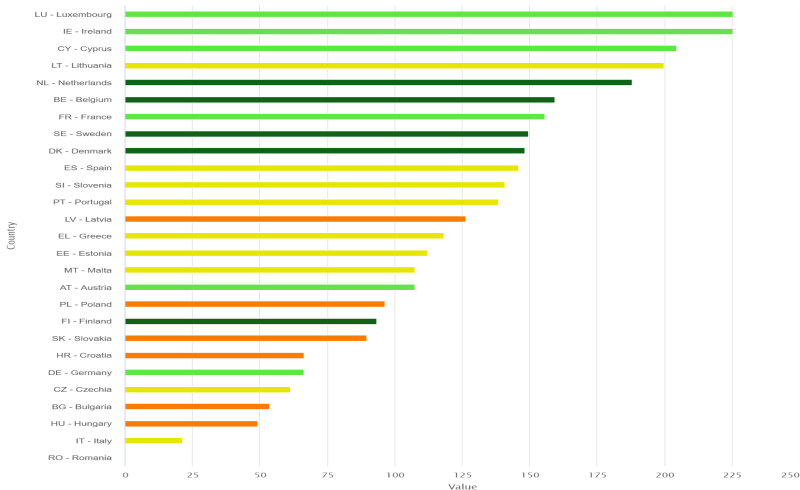
Source: European Innovation Scoreboard 2022



# EIS - Tertiary Education

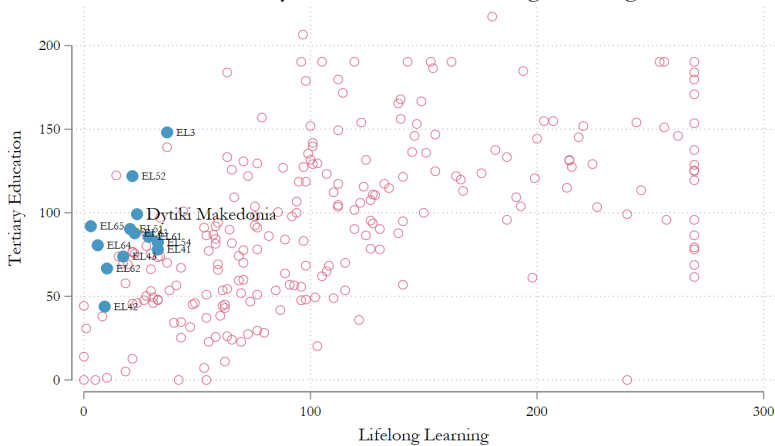
## 1.1.2 Population with tertiary education (Regional)

Source: European Innovation Scoreboard 2022



# Regional Innovation Scoreboard

## Tertiary Education and Lifelong Learning

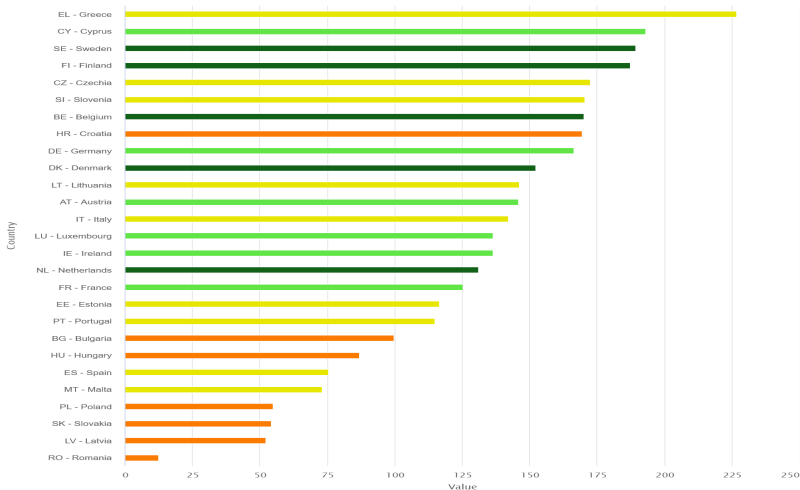


Score relative to EU average

# EIS - Innovative SMEs

## 3.1.1 SMEs introducing product innovations (Regional)

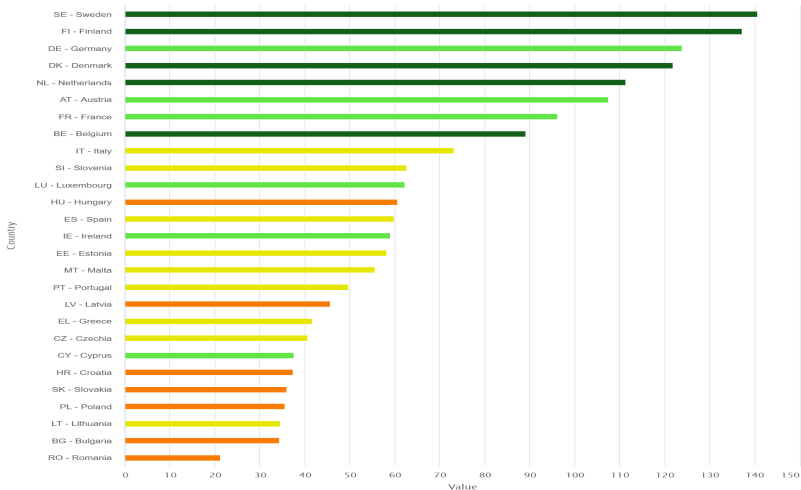
Source: European Innovation Scoreboard 2022



# EIS - Patent Applications

## 3.3.1 PCT patent applications (Regional)

Source: European Innovation Scoreboard 2022



# Green Innovation

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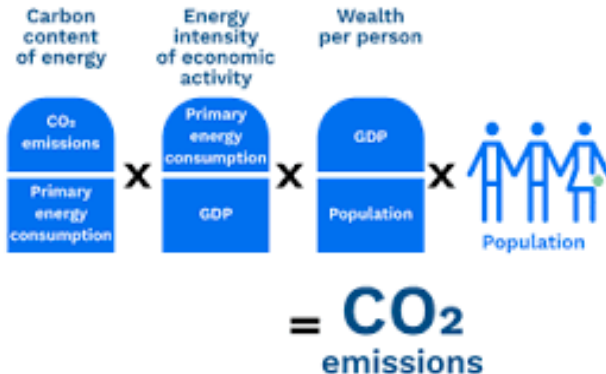
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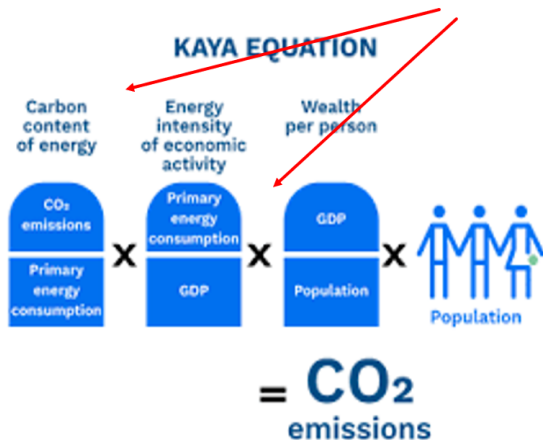
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- Fundamental to ↓ the costs of clean technologies below those of environment-harming technologies

# Kaya Identity

## KAYA EQUATION



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- *Innovation Systems* needed in place to foster New Technologies for CC Mitigation and Adaptation

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- Reshaping **Production, Financial System and Individual Behaviors** in the process

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- **IEA Net-zero Roadmap 2023**: technologies not yet available on the market → 35% of Emissions reductions needed for net zero compared to **50% in 2021**

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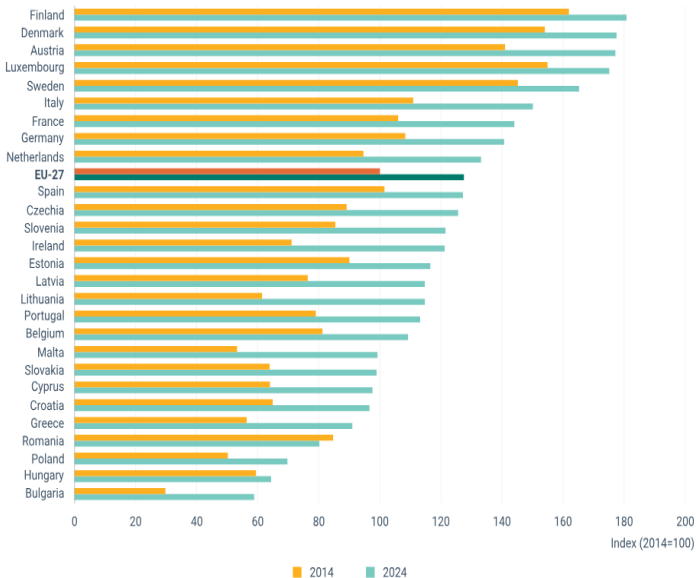
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- *Marked progress* across EU (2014-24) but still a gap between leaders and laggards



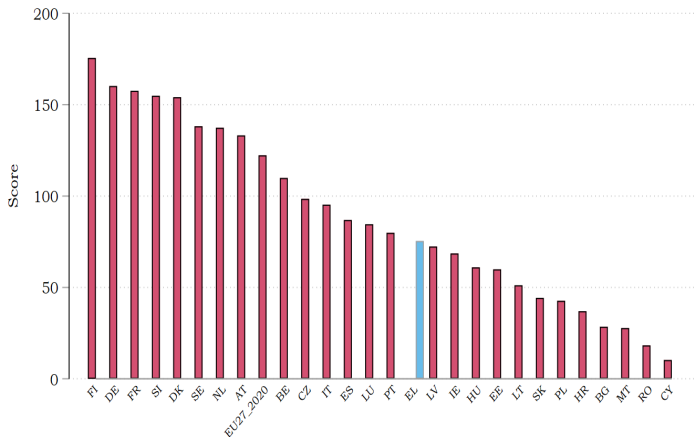
# EU Eco-Innovation Index 2014-24



# Eco-Innovation Outputs 24

Eco-Innovation Index 2024

Eco-Innovation Inputs



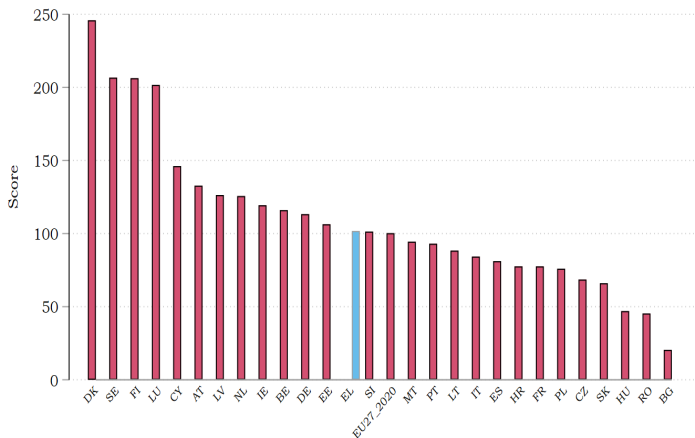
Source: EU Eco-Innovation Scoreboard

EU-27 2024=100

# Eco-Innovation Outputs 2024

Eco-Innovation Index 2024

Eco-Innovation Outputs



Source: EU Eco-Innovation Scoreboard

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# Green Technology Examples

- **Climate Change Mitigation**

- ▶ **Renewable Energy** - Solar, (onshore & offshore) Wind, Geothermal
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- **Climate Change Adaptation**

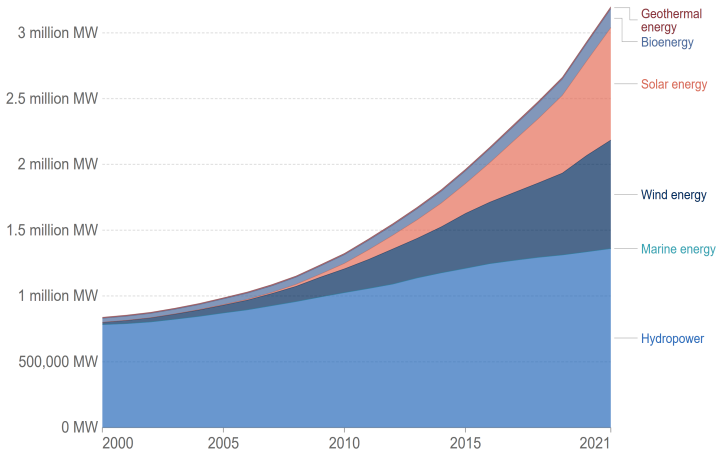
- ▶ **Green Rooftops & Green Facades**
- ▶ **Early Warning Systems** to warn communities about extreme weather events
- ▶ **Flexible Green Walls (*Concortainer*)**

# Renewable Energy on the Rise

## Installed global renewable energy capacity by technology

Installed global renewable energy capacity in megawatts (MW) by energy technology (hydropower, solar, wind, biomass, marine and geothermal)

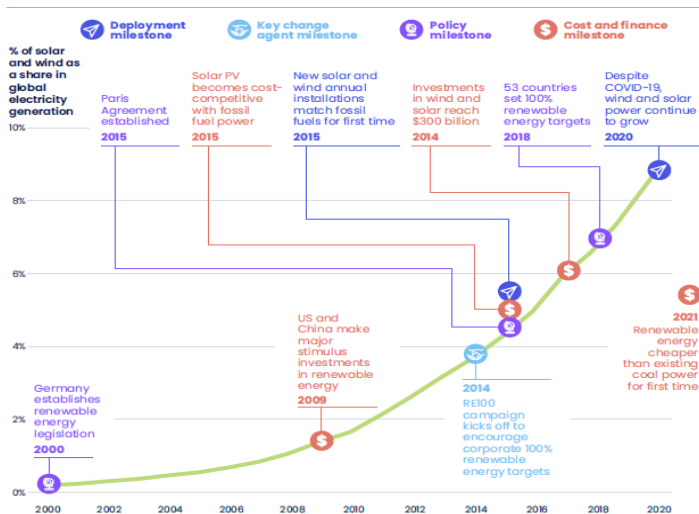
Our World  
in Data



Source: International Renewable Energy Agency (IRENA)

OurWorldInData.org/energy • CC BY

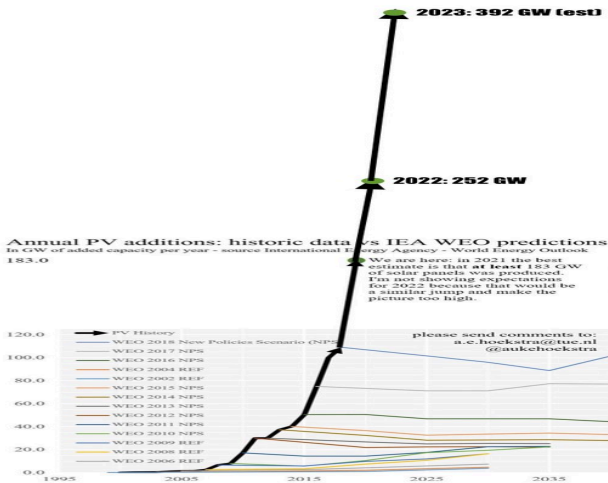
# Solar & Wind % in Total Energy



Note: PV = photovoltaics.

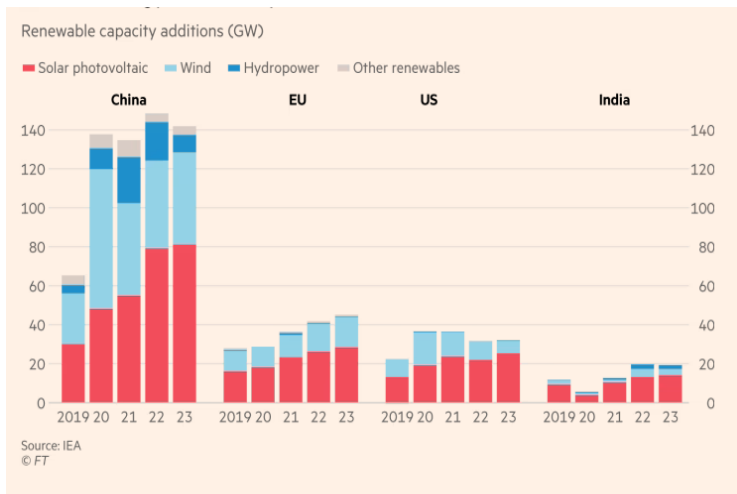
Source: Jaeger (2021).

# Solar PV Evolution





# Solar Capacity Key Player(s)

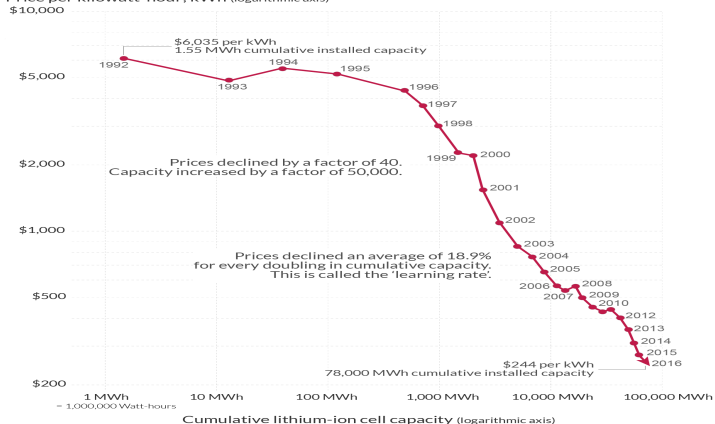


# Lithium Battery Costs

## Price and market size of lithium-ion batteries since 1992

Our World  
in Data

Price per kilowatt-hour; kWh (logarithmic axis)



Prices are adjusted for inflation and given in 2018 US-\$ per kilowatt-hour (kWh).

Source: Micah Ziegler and Jessika Trancik (2021). Re-examining rates of lithium-ion battery technology improvement and cost decline.

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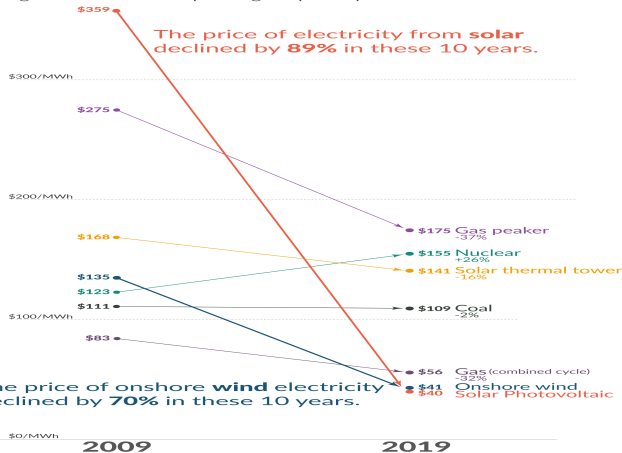
Licensed under CC-BY by the author Hannah Ritchie.

# Renewables Cost Efficiency

## The price of electricity from new power plants

Electricity prices are expressed in 'levelized costs of energy' (LCOE). LCOE captures the cost of building the power plant itself as well as the ongoing costs for fuel and operating the power plant over its lifetime.

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Data: Lazard Levelized Cost of Energy Analysis, Version 13.0

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