

Sustainable Development and Low Emissions Economies

Climate Resilient Development and Green Innovation

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*We can go for a walk where it's quiet and dry
And talk about precious things
Like love and law and poverty, ooh-oooh
(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
Accessible 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

Learning Objectives

- **Stocktaking of key Issues in Sustainable Development and Climate Change**

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- **Thinking as Economists!**

Economics Buzzwords

- **Incentives**

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- **Data**

- ▶ Key tool for *Evidence-based Policy*

Incentives everywhere

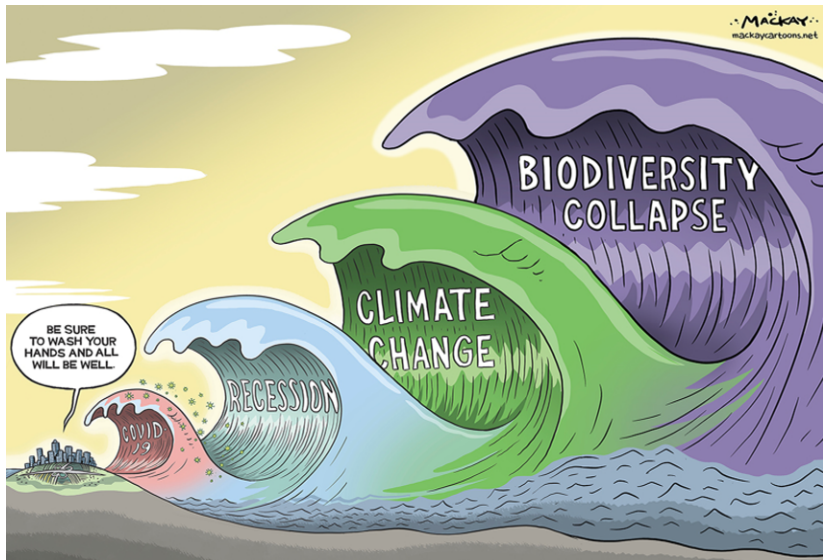
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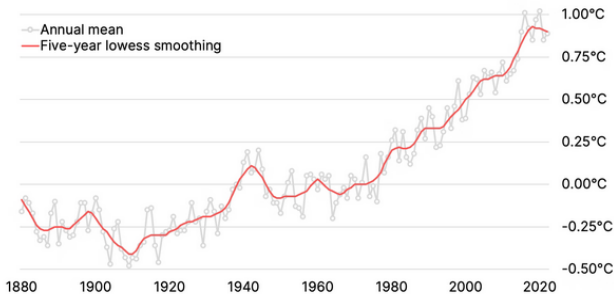
Poly-Crisis



Global Temperature on the Rise

Temperatures have risen 1°C

Temperatures are one degree Celsius above the long-term average



January 2023

Source:
NASA

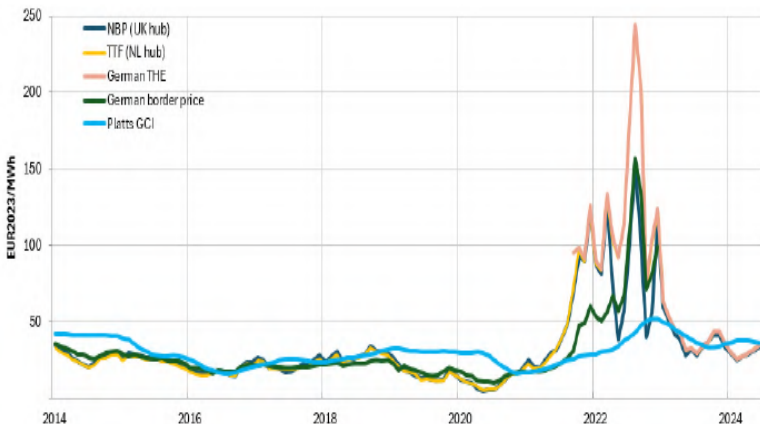
Note:
Land-ocean
temperature
index
(base period
1951-80)



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Energy Crisis - Wholesale Gas Prices

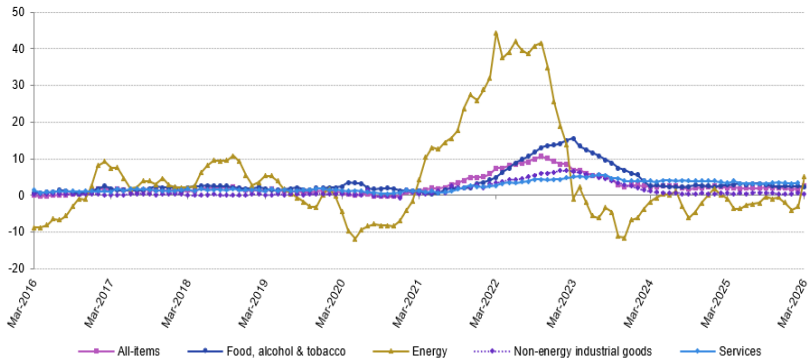


Source: Trinomics et al (2024), based on data from P Platts, Enerdata EnerMonthly

Cost of Living Crisis

Euro area annual inflation and its main components, March 2016-March 2026

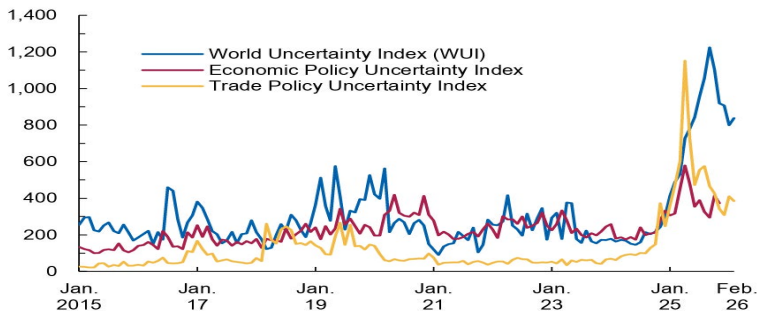
(%)



Source: Eurostat (online data code: prc_hicp_minr)

Uncertainty Transmissions

Figure 1.3. Global Uncertainty
(Index)



Sources: Ahir, Bloom, and Furceri 2022 (worlduncertaintyindex.com); Baker, Bloom, and Davis 2016 (policyuncertainty.com); and Caldara and others 2020 (matteoiacoviello.com/tpu.htm).

Note: The uncertainty measures are news- and media-outlets-based indices that quantify media attention to global news related to overall uncertainty (WUI), economic policy uncertainty, and trade policy uncertainty. WUI is divided by 100.

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

Sustainable Development Goals



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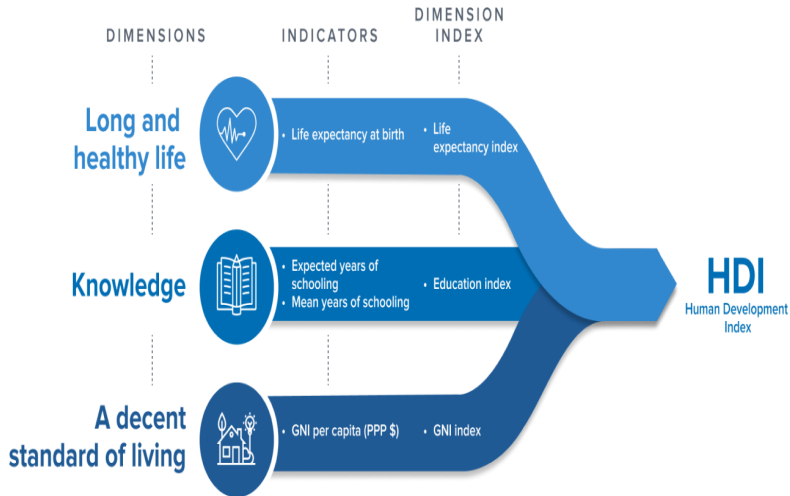
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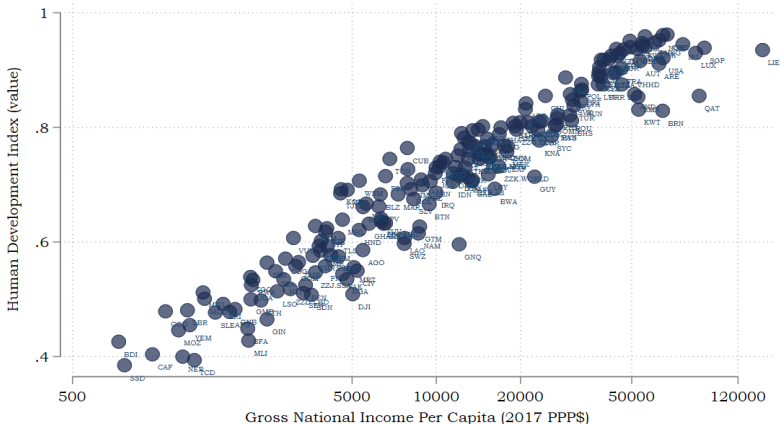
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- Associated with but *not Synonymous to Economic Growth*

Human Development Index Dimensions



Human vs(?) Economic Development

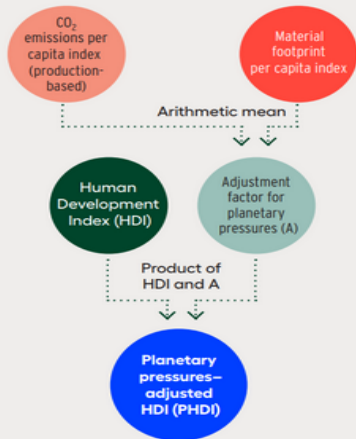
Human Development Index (value) and GNI pc 2021



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



A

1.000 PHDI = HDI

LOWER PLANETARY PRESSURES

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 - ▶ Climate Migration
 - ▶ Fiscal Burden

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

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- Weather-related extreme events in 2024 caused **\$304 billion** in global economic losses — a 58.9% increase from the 2010–14 annual average
- Combined global climate-health *productivity effects* across food, agriculture, built environment, and healthcare sectors → \$1.5 tr. by 2050

IPCC SIXTH ASSESSMENT REPORT (AR6)

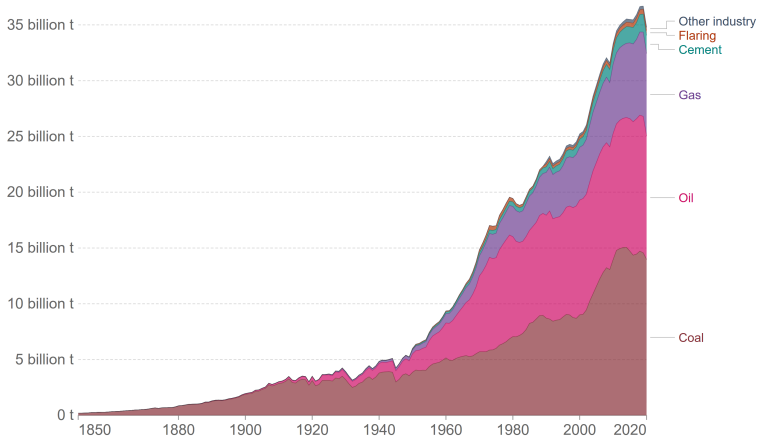
Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850–1900 in 2011–2020. Global greenhouse gas emissions have continued to increase, with unequal historical and ongoing contributions arising 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)

CO₂ Emissions by fuel

CO₂ emissions by fuel type, World

Annual carbon dioxide (CO₂) emissions from different fuel types, measured in tonnes per year.

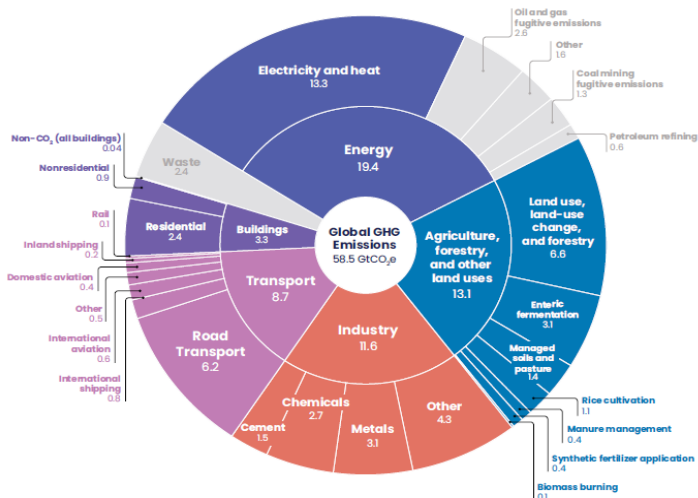
Our World
in Data



Source: Global Carbon Project

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

CO₂ Emissions by Sector

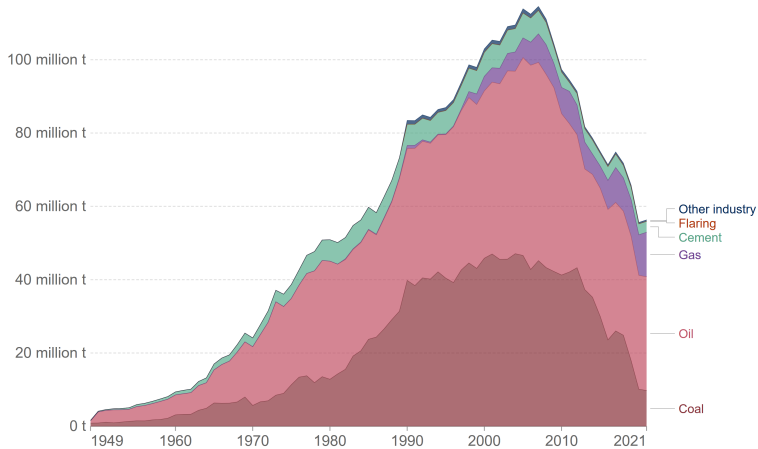


Notes: CO₂ = carbon dioxide; GHG = greenhouse gas; GtCO₂e = gigatonnes of carbon dioxide equivalent.

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)

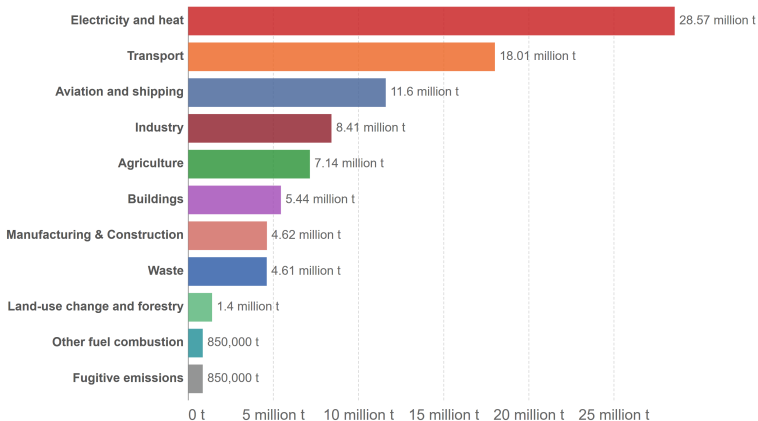
OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

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.



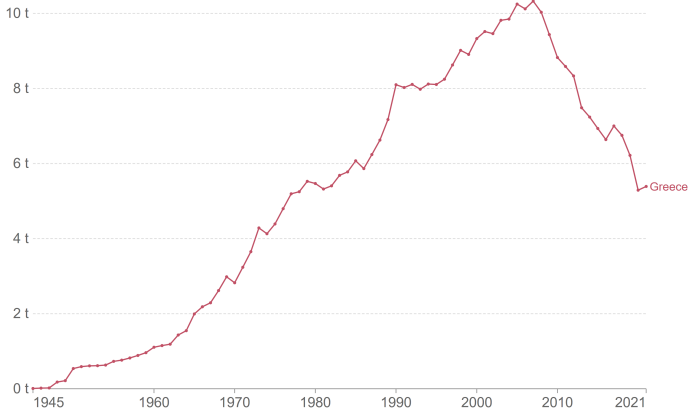
Source: Our World in Data based on Climate Analysis Indicators Tool (CAIT). OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

Greece CO₂ per capita

Per capita CO₂ emissions

Carbon dioxide (CO₂) emissions from fossil fuels and industry¹. 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 (CO₂) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO₂ 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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A human intervention to reduce emissions or enhance the sinks of greenhouse gases

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

Climate Targets and Commitments

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- **Behavioral Change**

Societal Shift towards Sustainable Practices

Climate Policies and Temperature

Global greenhouse gas emissions and warming scenarios

Our World
in Data

- 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

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 - 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.

Climate Resilient Development

IPCC Definition

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→ CRD possible when this interdependence is leveraged

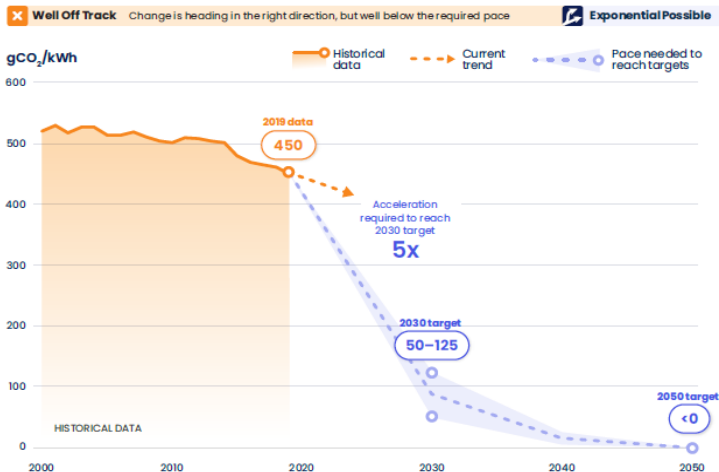
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- **Example:** Clean energy generation + healthy diets from sustainable food systems,+ universal health coverage and social protection
= Substantial **health and well-being co-benefits**

Energy Efficiency Trends and Needs



Notes: gCO₂/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

Innovation: The X Factor

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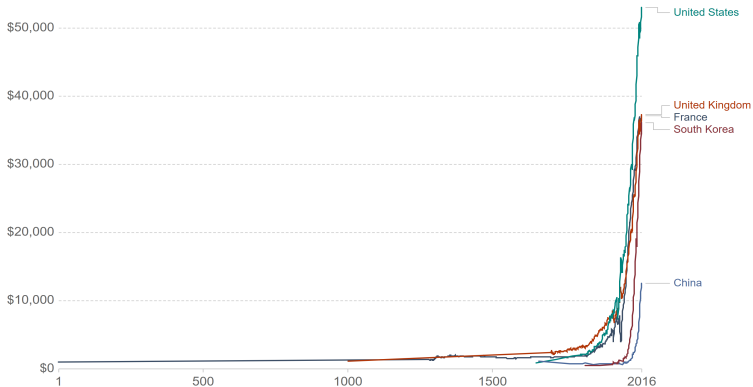
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- **Matt Ridley**: *Innovation is the child of freedom and the parent of prosperity. It is on balance a very good thing. We abandon it at our peril*

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.

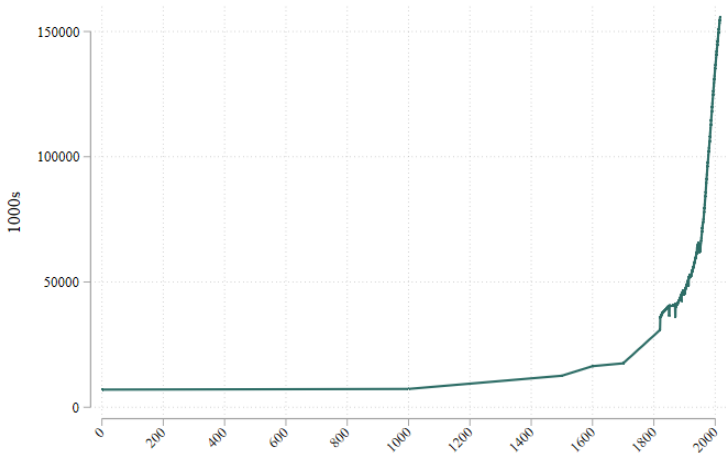


Source: Maddison Project Database (2018)

OurWorldInData.org/economic-growth • CC BY

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.

World Population

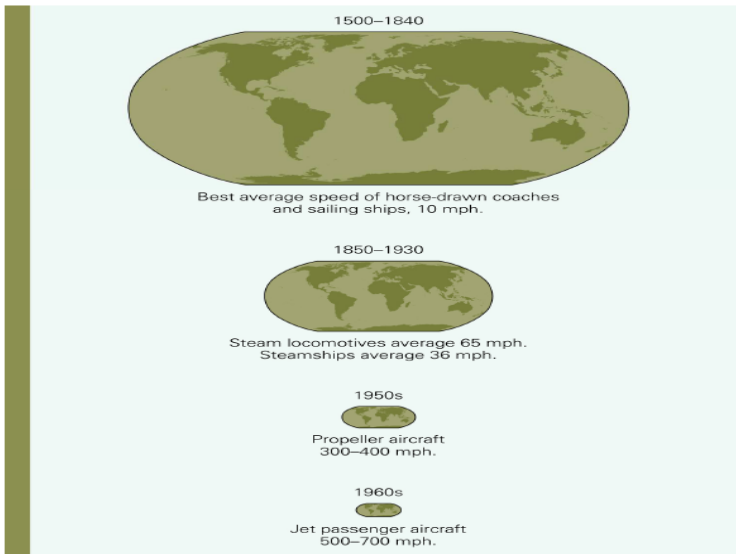


Source: Maddison (2008)

Embedded Human Knowledge



The Death of Distance



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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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- *There's no chance the iPhone is going to get significant market share. No chance.*

Steve Ballmer, chief executive of Microsoft 2007

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- Mokyr (2002)

What matters, clearly, is culture and institutions. Culture determines preferences and priorities. All societies have to eat but cultural factors determine whether the best and the brightest in each society will tinker with machines or chemicals , or whether they will perfect their swordplay or study the Talmud. Institutions set the incentives and penalty structure for people who suggest new techniques

Innovation and Institutions

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Chinese vs Columbus Flagship



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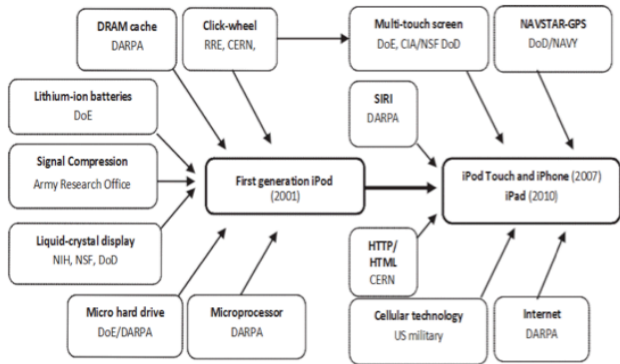
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- Strong Role of Government in US Innovation dominance (DARPA, Bell Labs) and Japanese & Korean tech boom after 1950

Public Sector and Smart Innovation

What makes the iPhone so 'smart'?



©MarianaMazzucato [The Entrepreneurial State: debunking private vs. public sector myths](#), p. 109, Fig. 13

Innovation Promotion Toolbox

Innovation Policy Toolkit

Policy	Quality of evidence	Conclusiveness of evidence	Net benefit	Time frame	Effect on inequality
	(1)	(2)	(3)	(4)	(5)
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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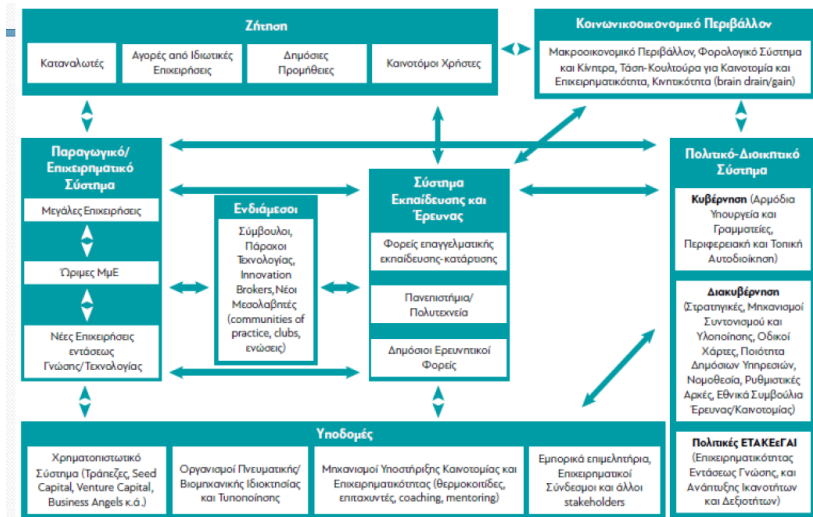
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- National and Regional Innovation Systems foster *Creation and Dissemination* of Innovation

National Innovation System (DIANEOSIS)



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

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- **Vested Interest**

Incumbents lobbying against change, low incentive to innovate

European Innovation Scoreboard

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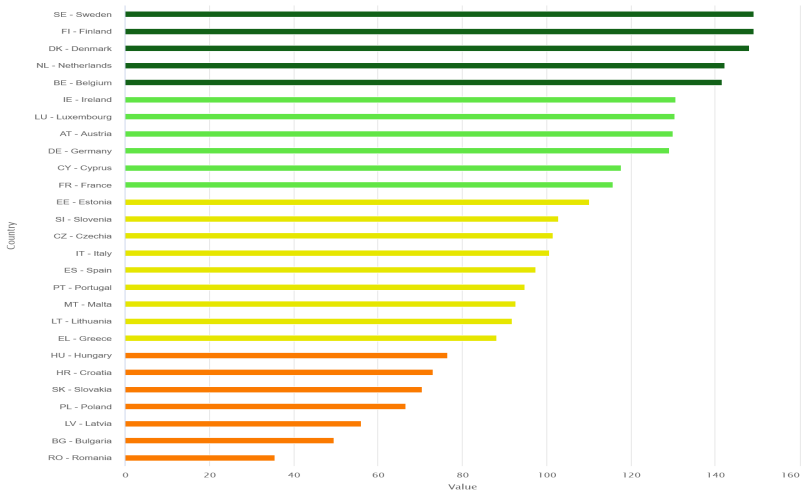
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EIS - Summary Innovation Index

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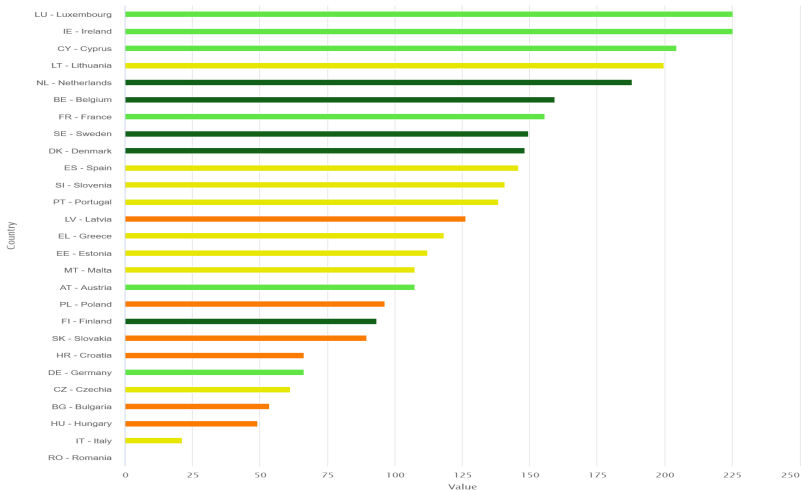
Source: European Innovation Scoreboard 2022



EIS - Tertiary Education

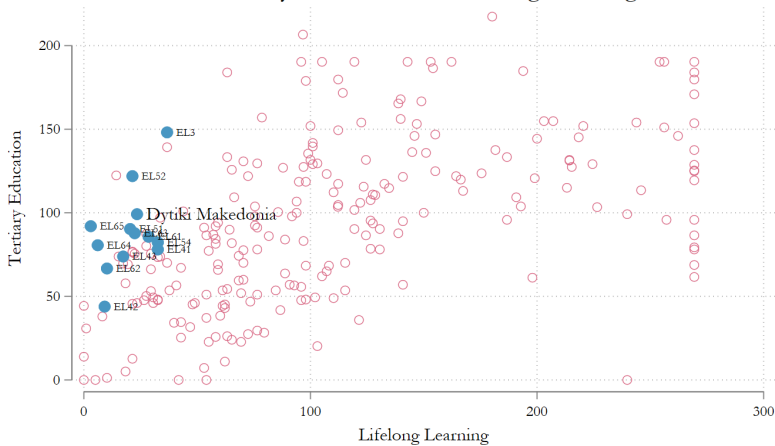
1.1.2 Population with tertiary education (Regional)

Source: European Innovation Scoreboard 2022



Regional Innovation Scoreboard

Tertiary Education and Lifelong Learning

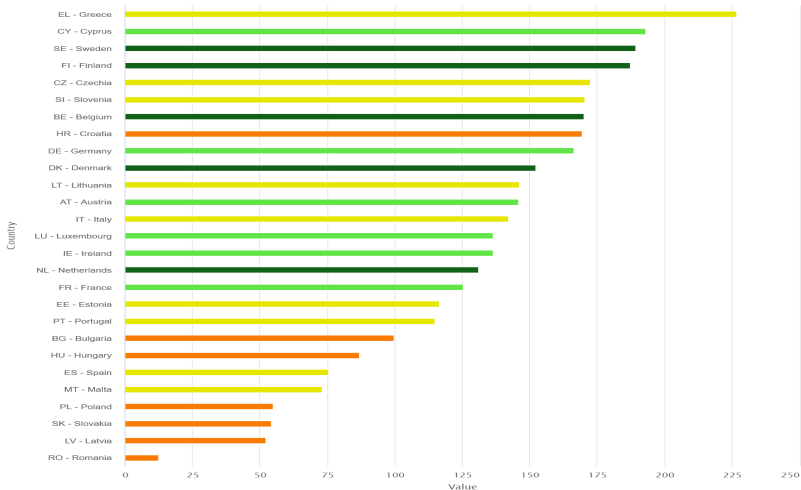


Score relative to EU average

EIS - Innovative SMEs

3.1.1 SMEs introducing product innovations (Regional)

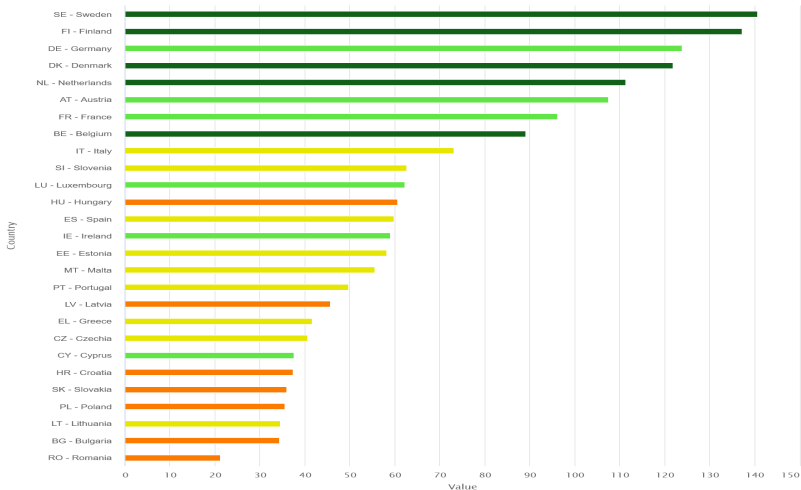
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EIS - Patent Applications

3.3.1 PCT patent applications (Regional)

Source: European Innovation Scoreboard 2022



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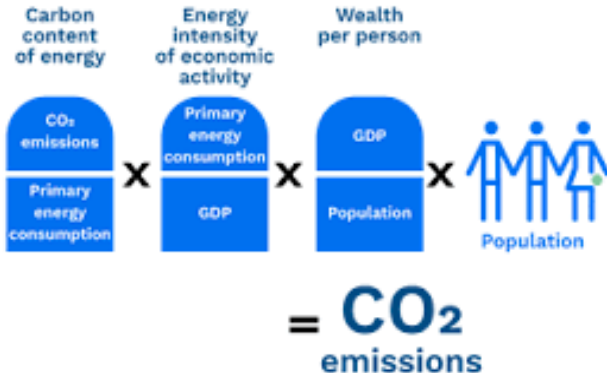
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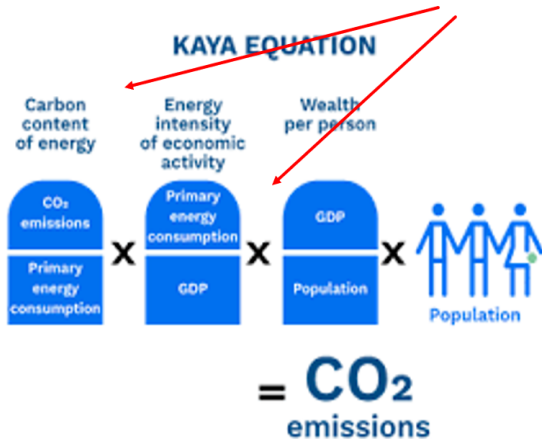
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- Fundamental to ↓ the costs of clean technologies below those of environment-harming technologies

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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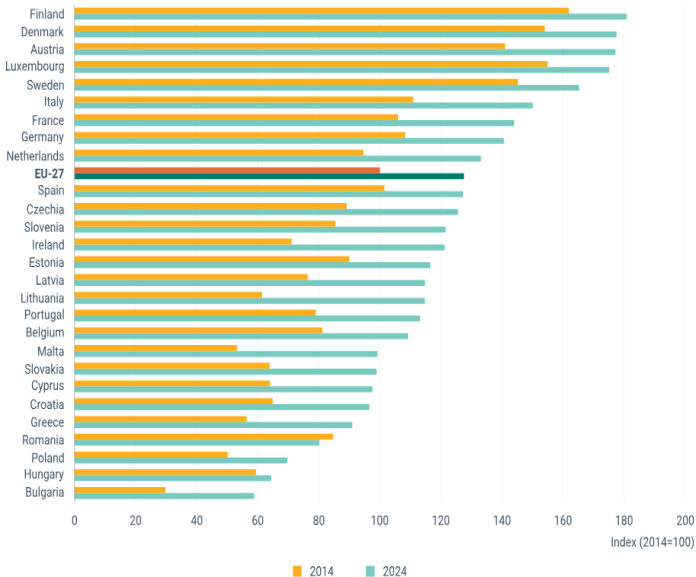
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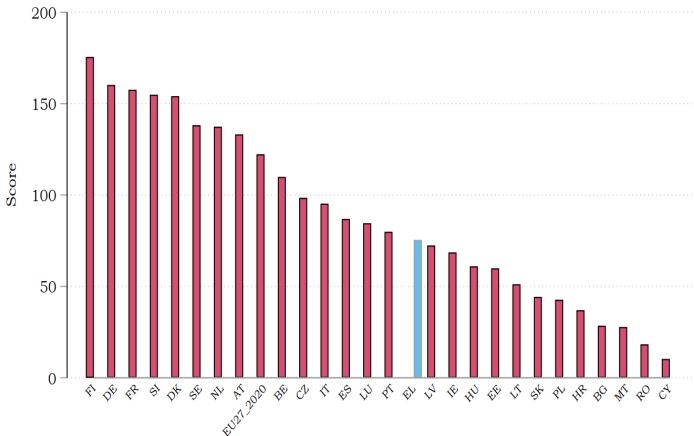
EU Eco-Innovation Index 2014-24



Eco-Innovation Inputs 2024

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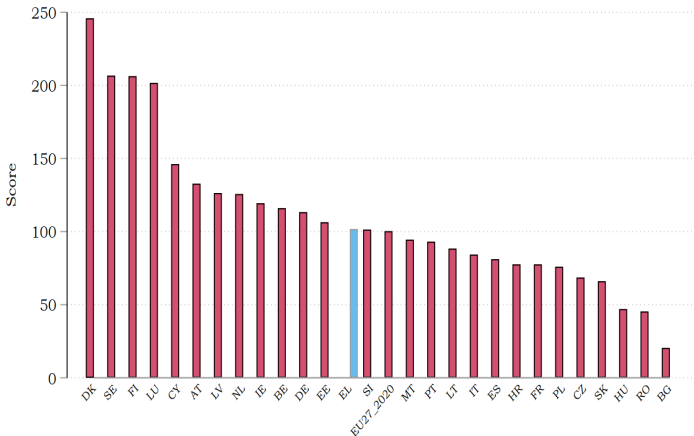
Source: EU Eco-Innovation Scoreboard

EU-27 2024=100

Eco-Innovation Outputs 2024

Eco-Innovation Index 2024

Eco-Innovation Outputs



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Green Technology Examples

- **Climate Change Mitigation**

- ▶ **Renewable Energy** - Solar, (onshore & offshore) Wind, Geothermal
- ▶ **Carbon capture and storage (CCS), *Direct Air Capture***
- ▶ **Energy efficiency improvements** - Smart Grids, Building Energy Management Systems

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- ▶ **Renewable Energy** - Solar, (onshore & offshore) Wind, Geothermal
- ▶ **Carbon capture and storage (CCS), *Direct Air Capture***
- ▶ **Energy efficiency improvements** - Smart Grids, Building Energy Management Systems

- **Climate Change Adaptation**

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

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- Electricity generations from fossil fuels ↓ for the first time in India & China in 2025

Good News

Share of electric vehicles in light-duty vehicle sales (%)



Share of solar and wind in electricity generation (%)



Ratio of investment in low-carbon to fossil fuel energy supply

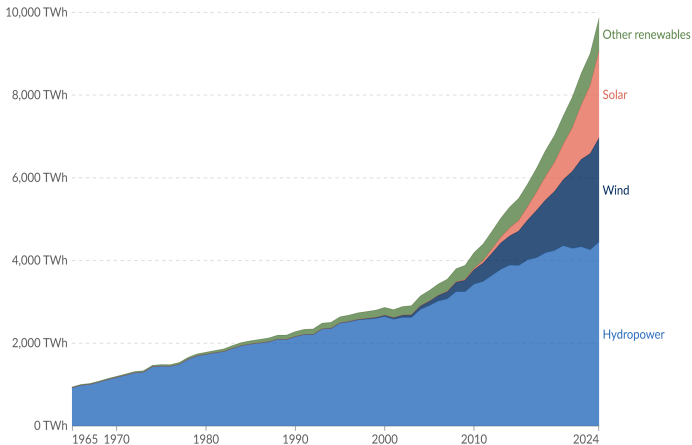


KONSTANTINOS DELLIS (kdellis@aueb.gr) is signed in

Sources: IEA 2025i, 2025k; Ember 2025.

Renewable Energy on the Rise

Renewable electricity generation, World

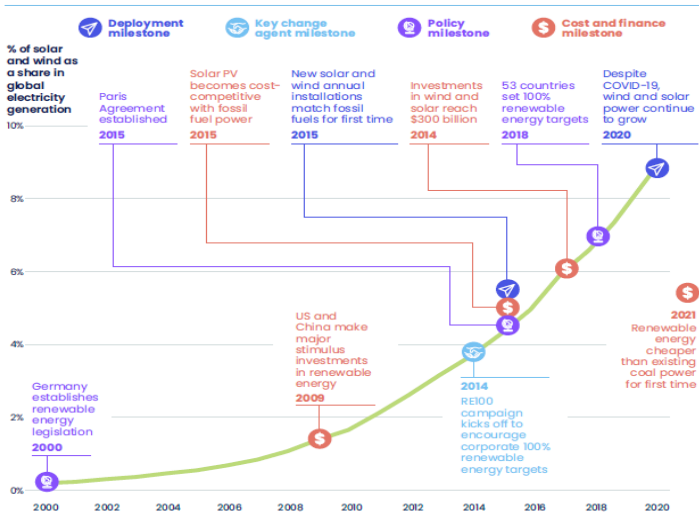


Data source: Energy Institute - Statistical Review of World Energy (2025)

OurWorldinData.org/renewable-energy | CC BY

Note: 'Other renewables' refers to renewable sources including geothermal, biomass, waste, wave and tidal. Traditional biomass is not included.

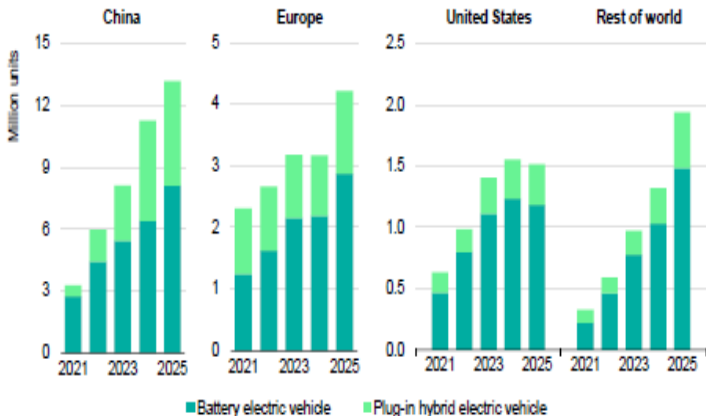
Solar & Wind % in Total Energy



Note: PV = photovoltaics.
Source: Jaeger (2021).

EV Sales

Electric car sales in selected markets, 2021-2025



IEA. CC BY 4.0.

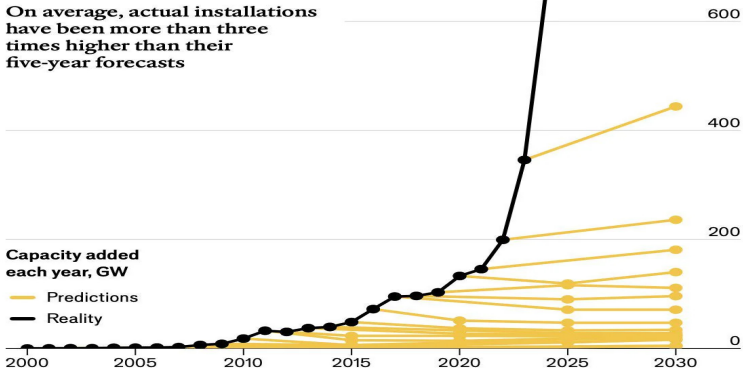
Source: IEA analysis based on data from ACEA, EAFO, EV Volumes and Marklines.

Solar PV Evolution

↓ **EASY PV**

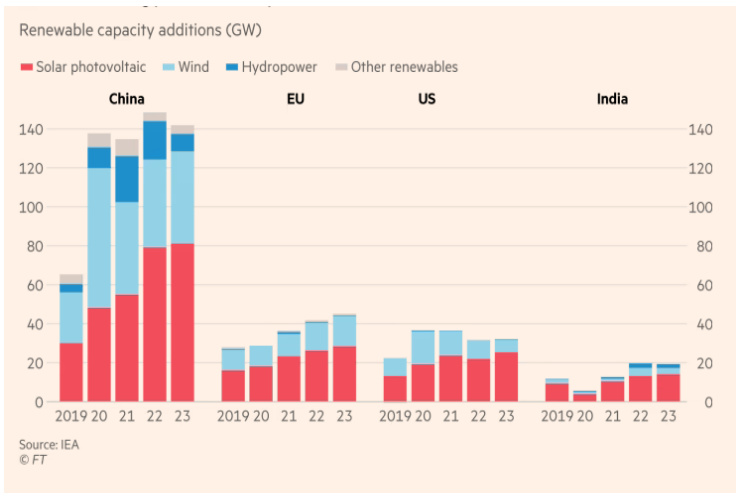
how solar outgrew expectations

On average, actual installations have been more than three times higher than their five-year forecasts



Sources: IEA; Energy Institute; BloombergNEF

Solar Capacity Key Player(s)

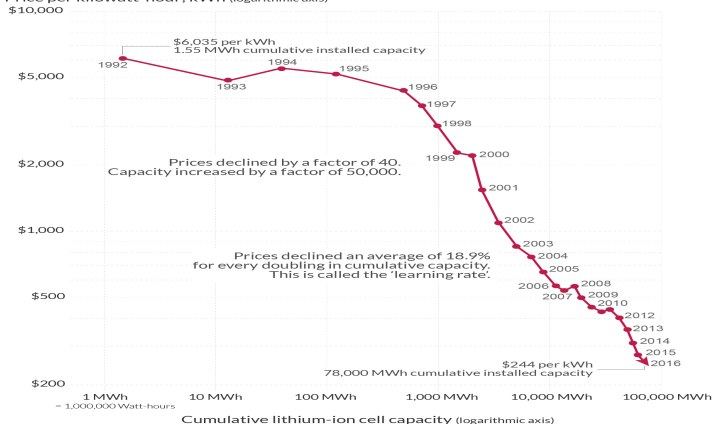


Lithium Battery Costs

Price and market size of lithium-ion batteries since 1992

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Price per kilowatt-hour; kWh (logarithmic axis)



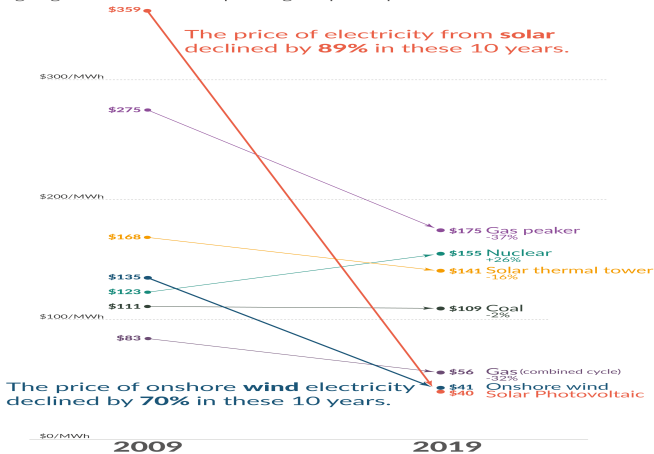
Prices are adjusted for inflation and given in 2018 US-\$ per kilowatt-hour (kWh).
Source: Micah Ziegler and Jessika Trancik (2021), Re-examining rates of lithium-ion battery technology improvement and cost decline.
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Renewables Cost Efficiency

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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