The Trajectory of the Energy Transition – in Japan and the World

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2025 BREAKTHROUGH OF THE YEAR

GOOD MORNING, SUNSHINE

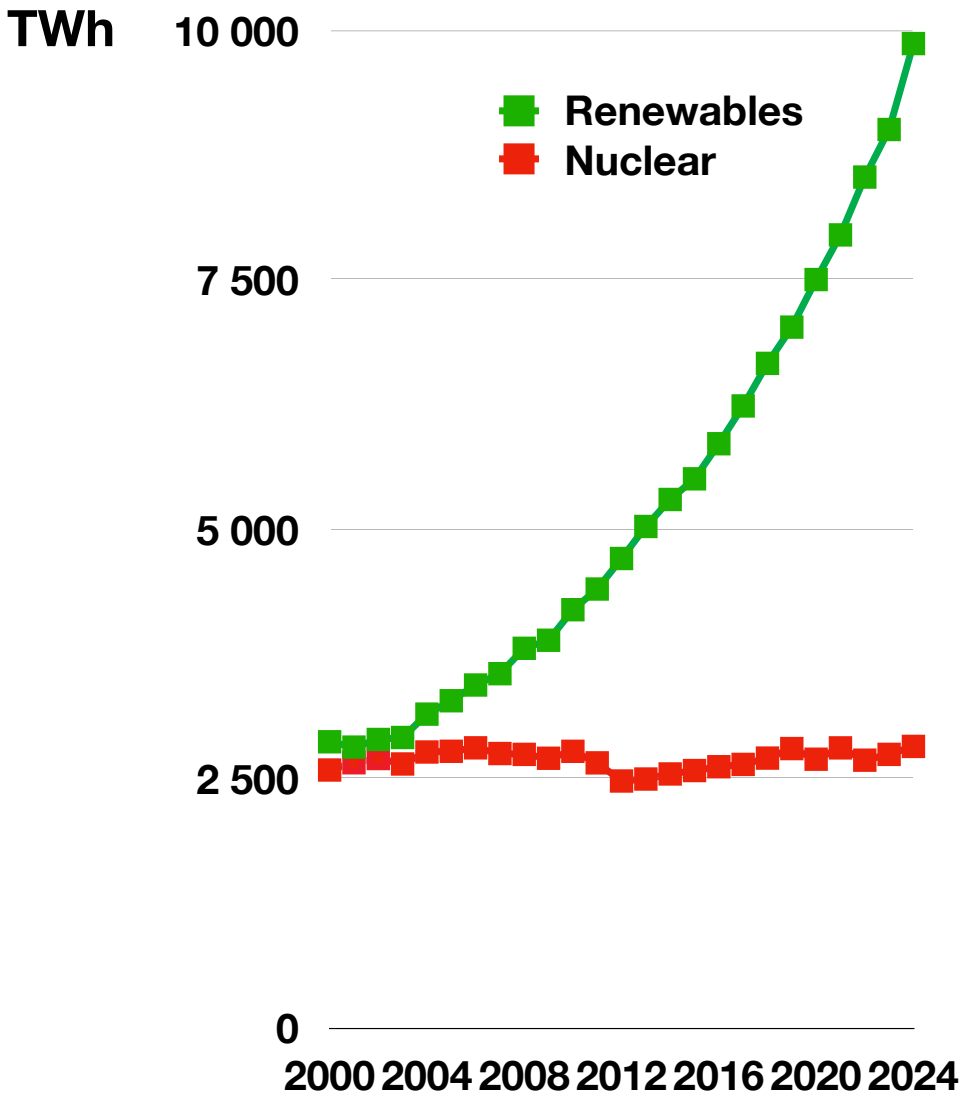
The seemingly unstoppable growth of renewable energy is *Science*'s 2025 Breakthrough of the Year

BY TIM APPENZELLER

Since the Industrial Revolution, human society has run on ancient solar energy—captured by plants hundreds of millions of years ago, stored in fossil fuels, and dug and drilled from the earth. But this year momentum shifted unmistakably toward the energy that streams from the Sun today. Renewable energy, most of it from sunlight itself or from wind, ultimately driven by the Sun, overtook conventional energy on multiple fronts.

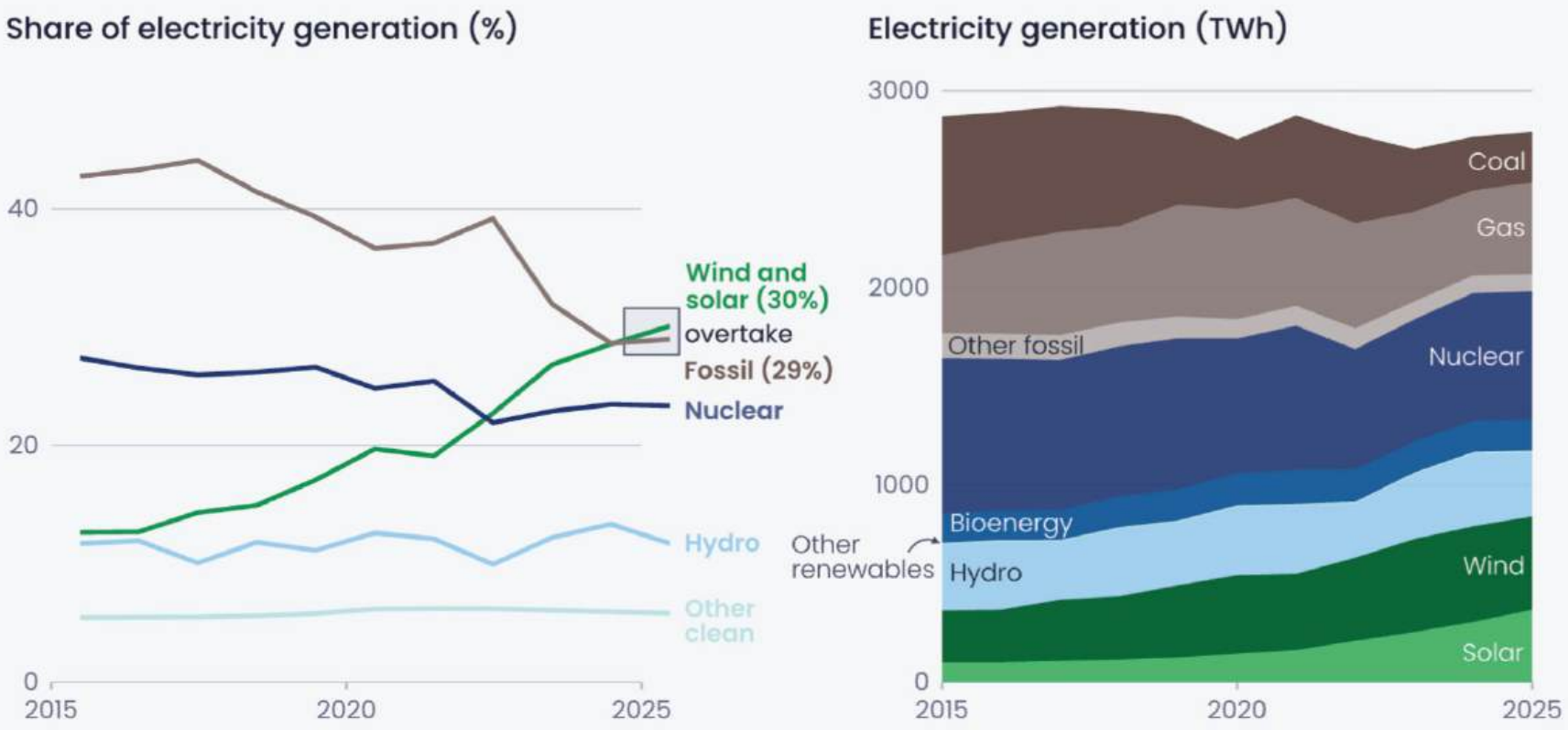
This year, renewables surpassed coal as a source of electricity worldwide, and solar and wind energy grew fast enough to cover the entire increase in global electricity use from January to June, according to energy think tank Ember

Global non-fossil electricity production 2000-2024



Data: Statistical review of World Energy 2025

Wind and solar overtake fossil power in the EU for the first time in 2025



Source: Yearly electricity data, Ember

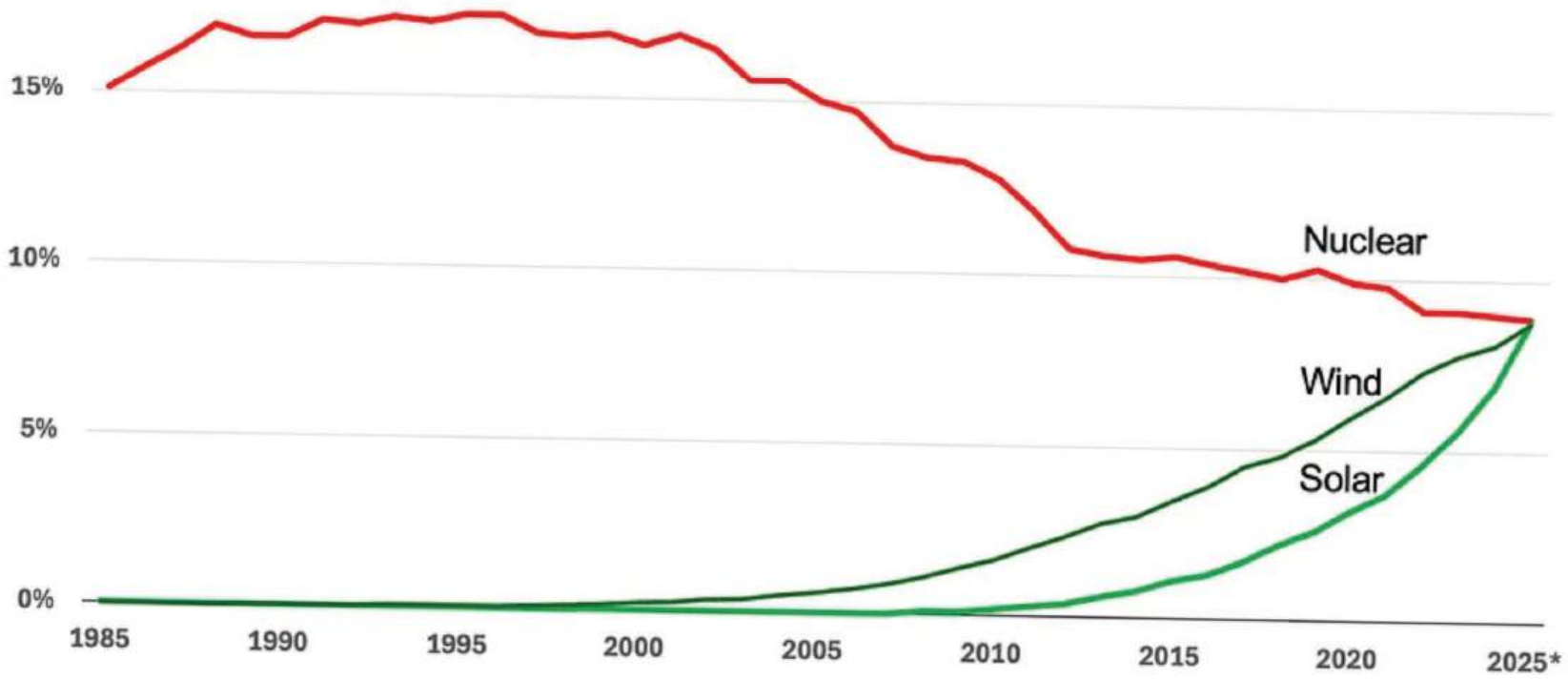
Other clean includes bioenergy and other renewables. Fossil includes coal, gas and other fossil.

EMBER

Sources of clean power, 1985 – 2025

(% of global power generation)

Liebreich Associates



* Full year estimate based on January - November

Source: Ember/Energy Institute Statistical Review; Liebreich Associates

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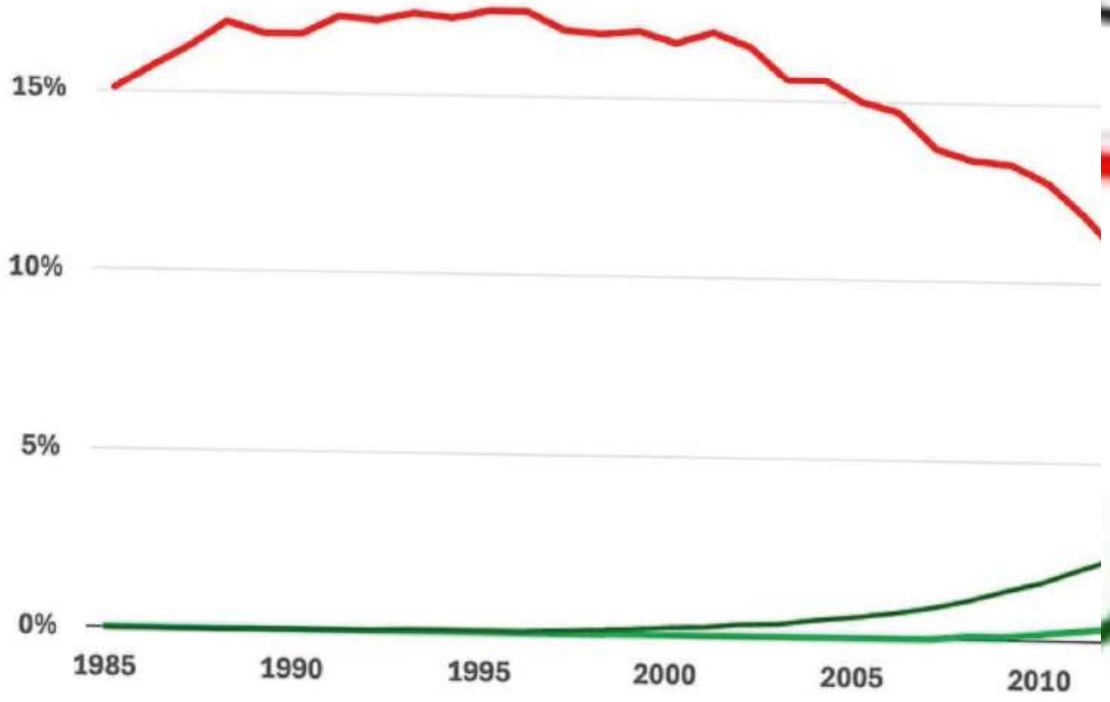

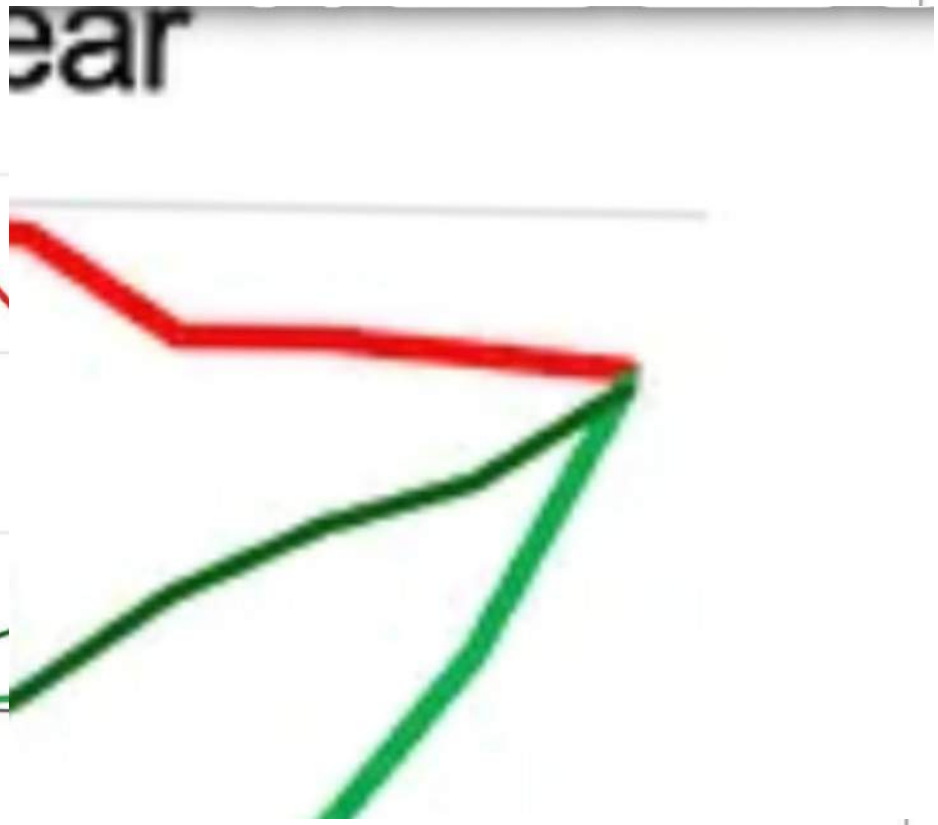

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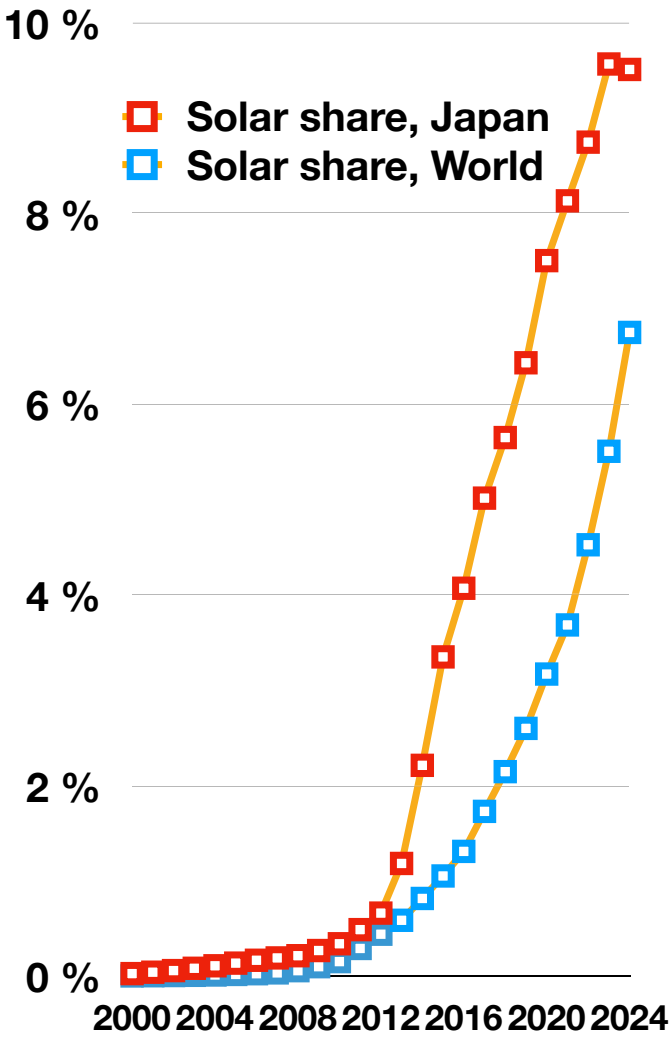
Japan and the World



Data: Statistical review of World Energy 2025

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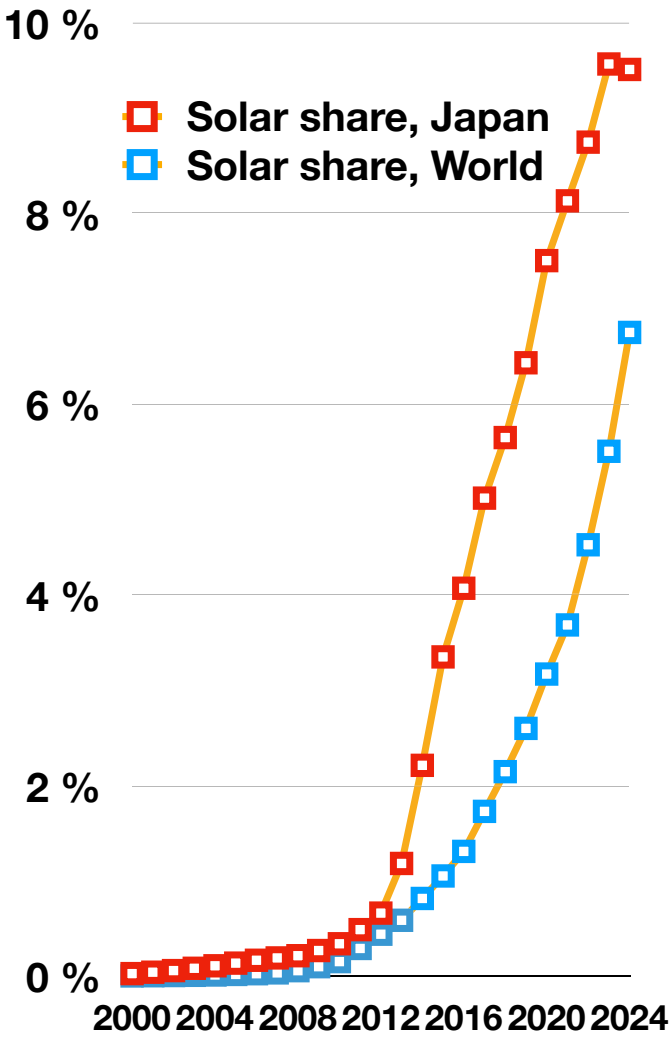

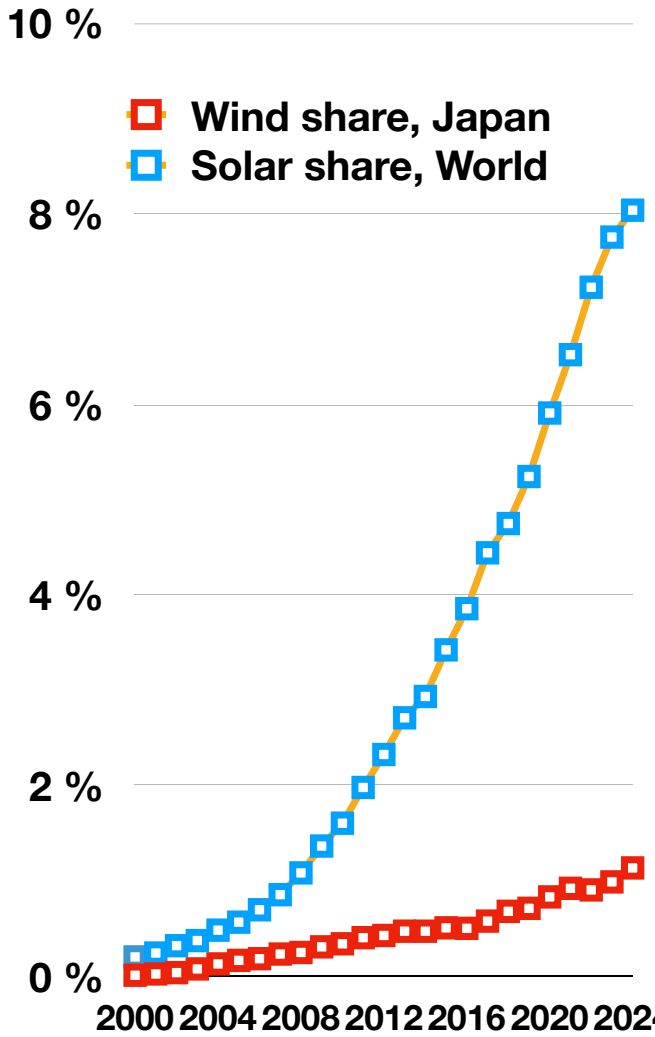

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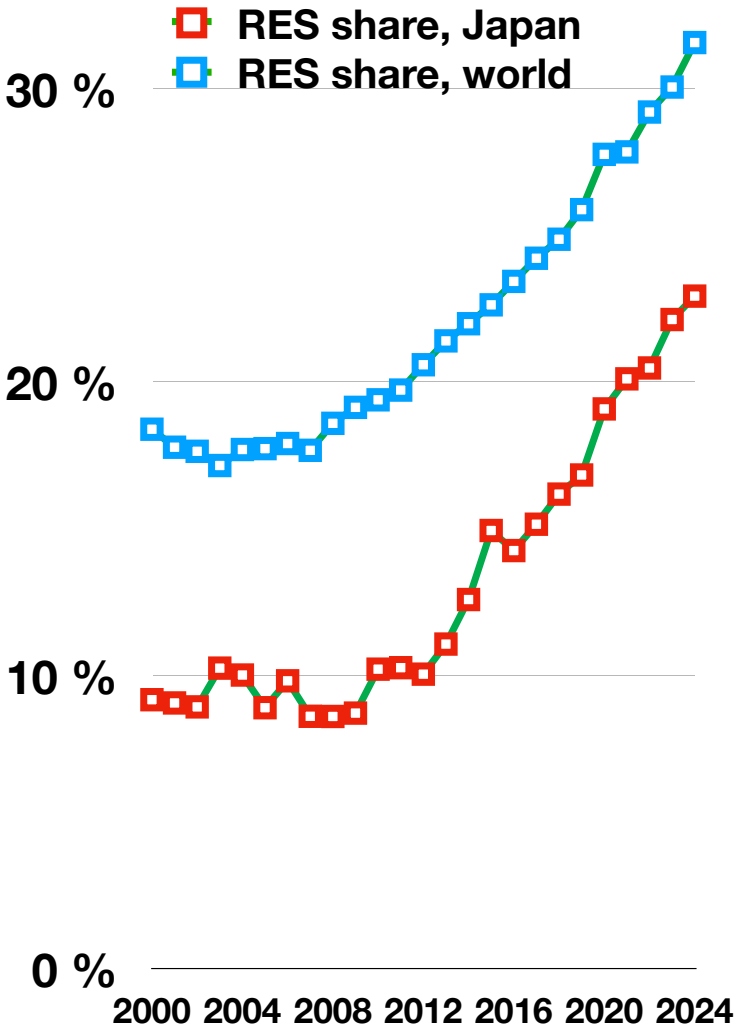

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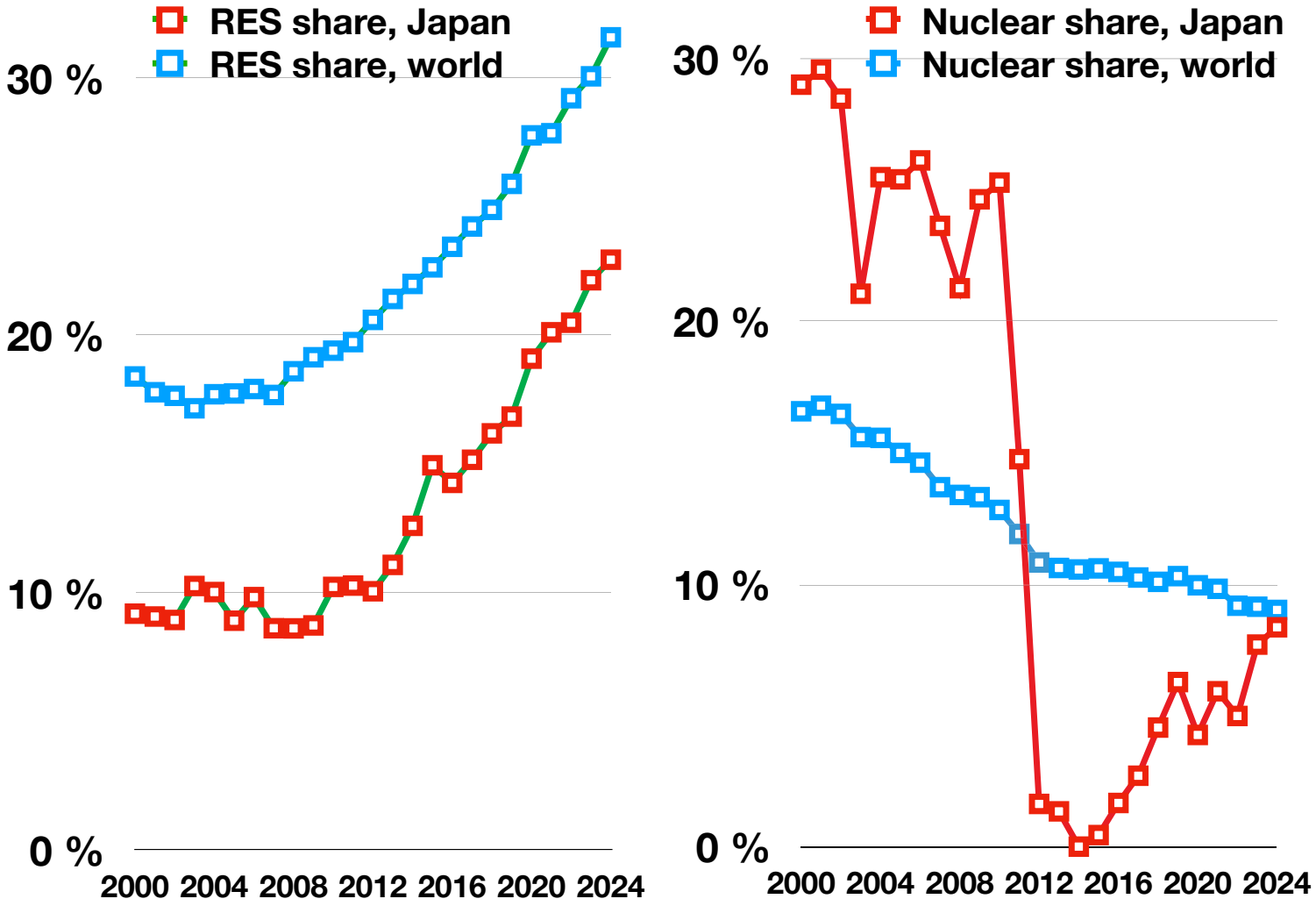

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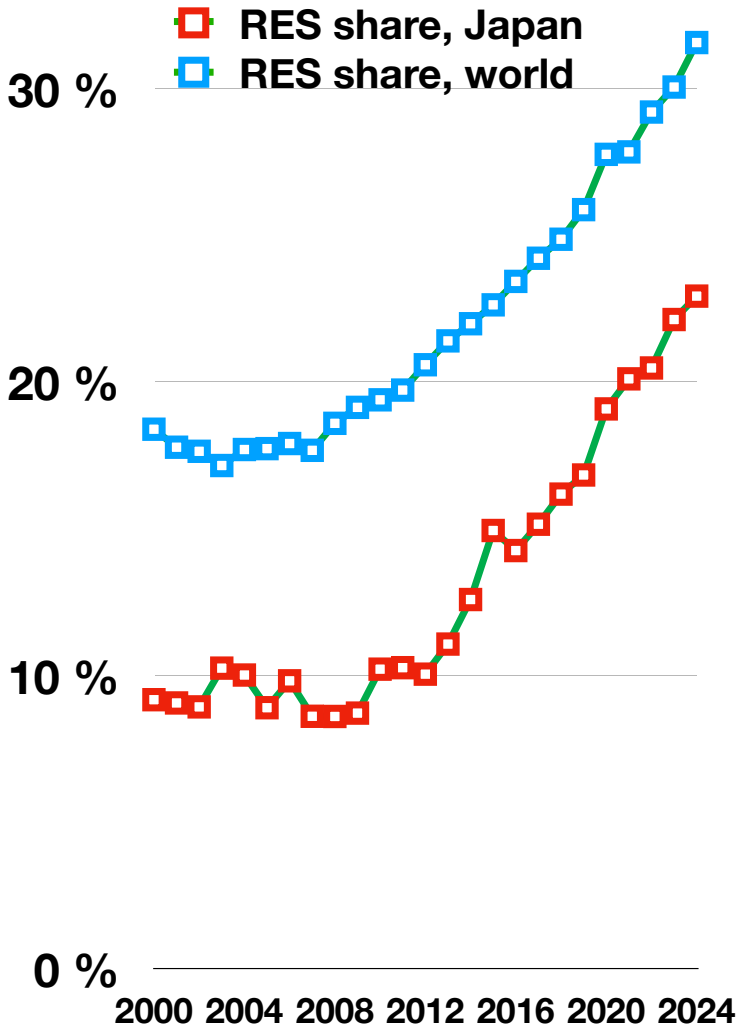
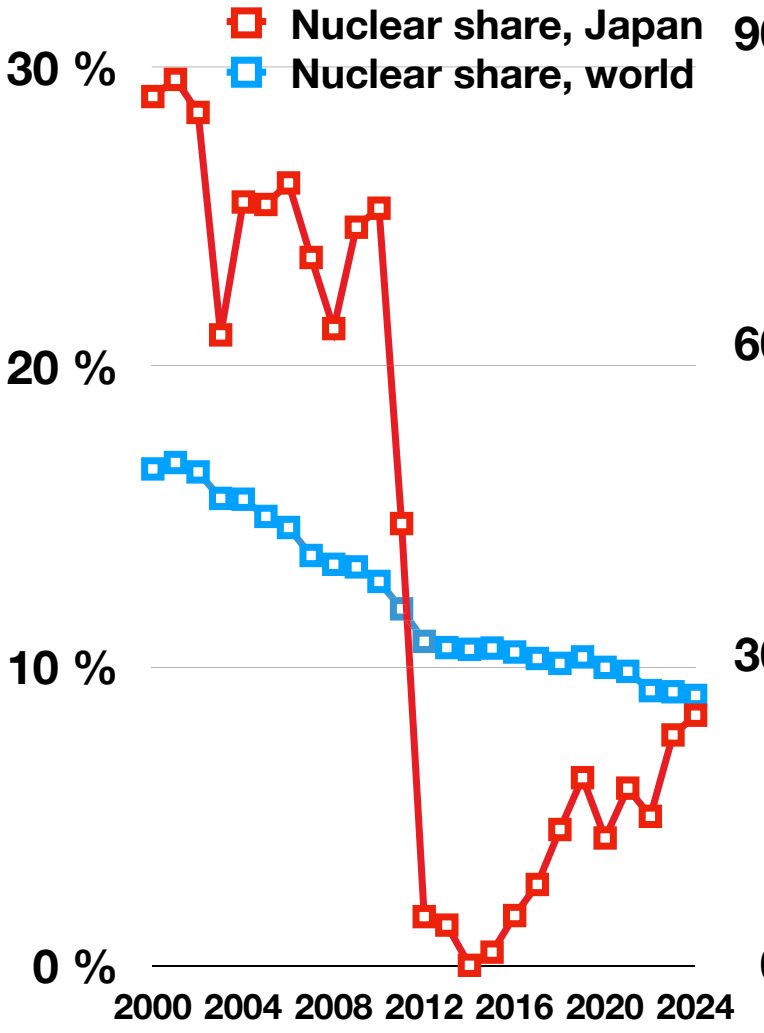
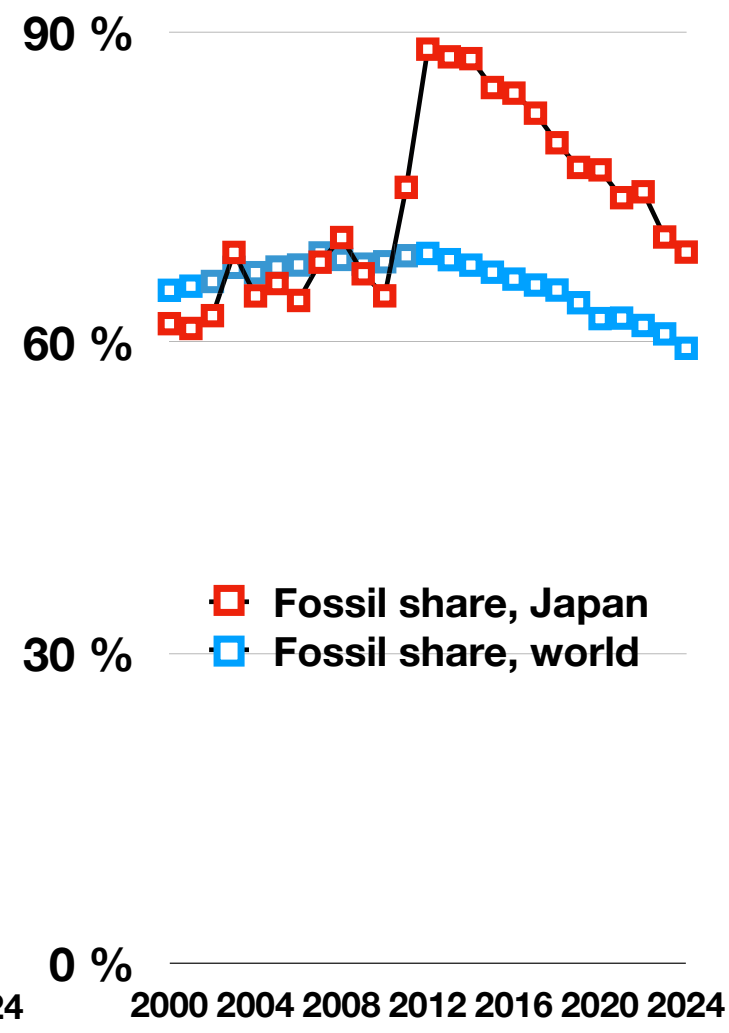
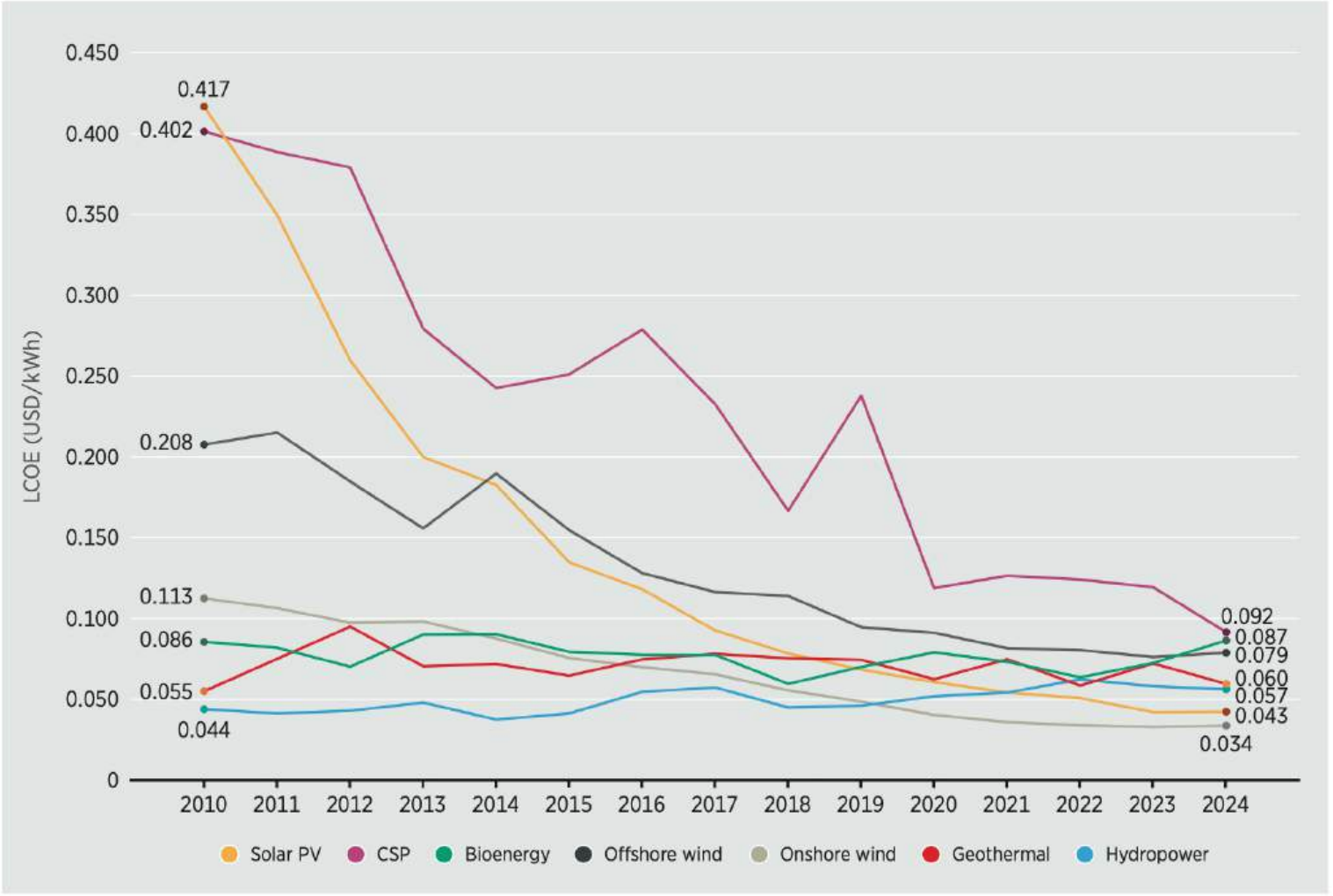






Costs are falling

Figure S1 Renewable energy LCOE decline, 2010-2024



Notes: CSP = concentrated solar power; kWh = kilowatt hour; LCOE = levelised cost of electricity; PV = photovoltaic; USD = United States dollar.

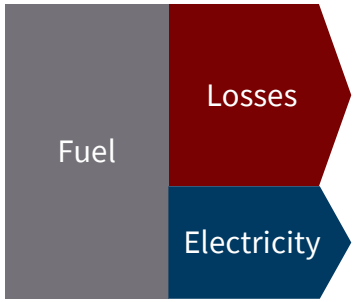
Renewable electricity more efficient than fuels

Electricity production

Electricity

Fossil thermal

30-40% efficiency



Wind and solar

100% efficiency

2-3x

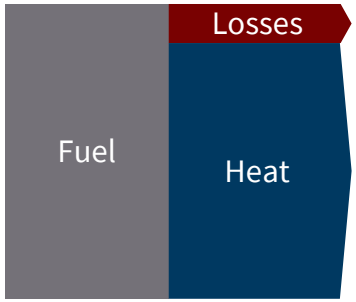
as efficient

Electricity utilization

Heating

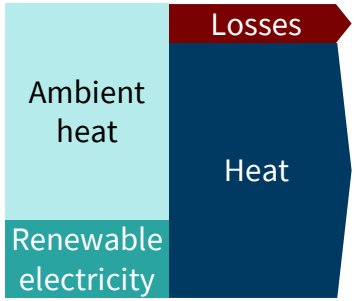
Gas boiler

85% efficiency



Heat pump

300-400% efficiency



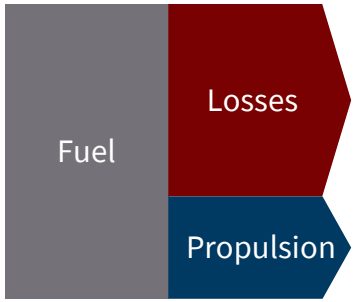
3-4x

as efficient

Transport

Internal com-bustion engine

25-40% efficiency



Electric vehicle

80-90% efficiency

2-4x

as efficient

Source: IEA, IIASA, RMI analysis, Adapted from Prof. Tomas Kaberger. Note: Solar & wind's 100% efficiency represents the fact that there are no conversion losses from primary to secondary energy.

Copernicus Global Climate Report 2024 confirms last year as the warmest on record, first ever above 1.5°C annual average temperature

Fri, 10/01/2025 - 12:00
Print to pdf

The *Copernicus Global Climate Highlights Report 2024*, published today, confirms 2024 as the warmest year on record and the **first to exceed 1.5°C above pre-industrial levels for the annual global average temperature**. Last year was also the warmest for all continental regions, including Europe, except Antarctica and Australasia.

Copernicus Global Climate Report 2024

WORLD METEOROLOGICAL ORGANIZATION

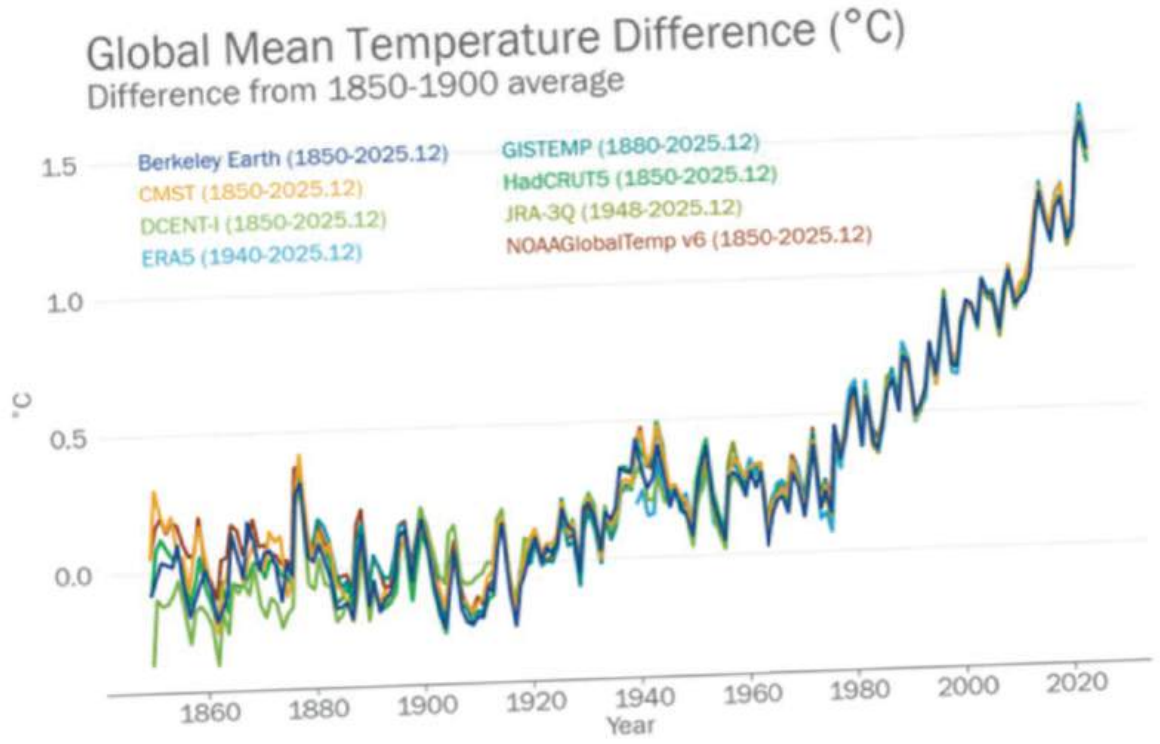


Figure 1: Annual global mean temperature anomalies relative to the 1850-1900 average shown from 1850 to 2025 for eight datasets as shown in the legend.

Copernicus Global Climate

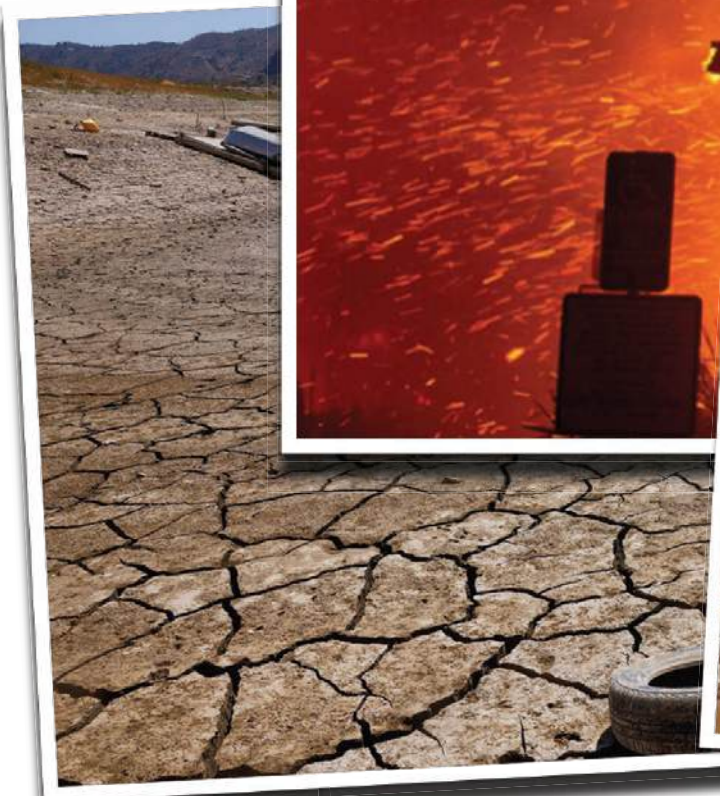
WORLD METEOROLOGICAL ORGANIZATION

Global Mean Temperature Difference (°C)

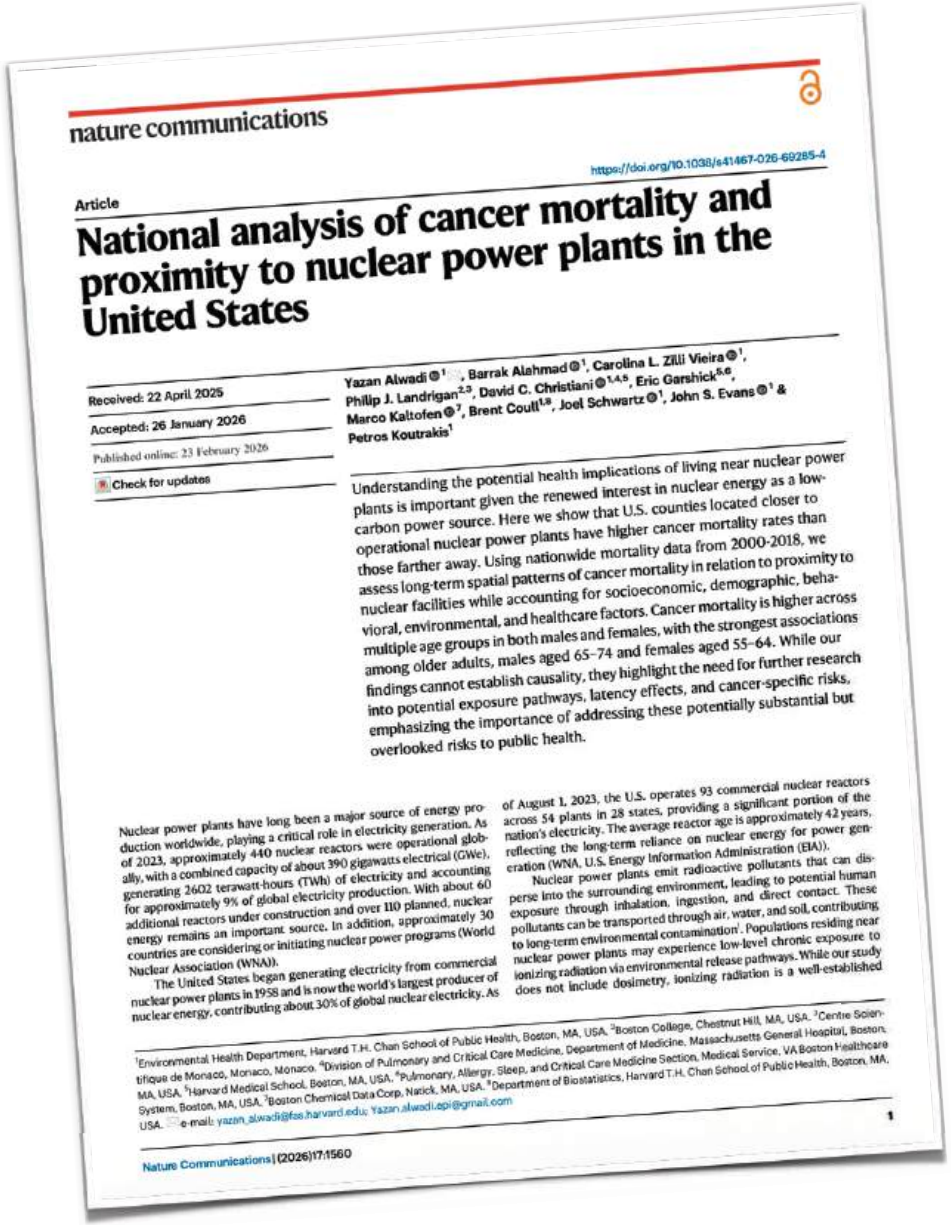
1900 average shown

OGICAL
TION

900 average shown



Radiation Health Effects



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Article

National analysis of cancer mortality and proximity to nuclear power plants in the United States

Received: 22 April 2025

Accepted: 26 January 2026

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Check for updates

Yazan Alwadi[1], Barrak Alahmad[1], Carolina L. Zilli Vieira[1], Philip J. Landrigan[2,3], David C. Christiani[1,4,5], Eric Garshick[5,6], Marco Kaltofen[7], Brent Coull[1,8], Joel Schwartz[1], John S. Evans[1] & Petros Koutrakis[1]

Understanding the potential health implications of living near nuclear power plants is important given the renewed interest in nuclear energy as a low-carbon power source. Here we show that U.S. counties located closer to operational nuclear power plants have higher cancer mortality rates than those farther away. Using nationwide mortality data from 2000-2018, we assess long-term spatial patterns of cancer mortality in relation to proximity to nuclear facilities while accounting for socioeconomic, demographic, behavioral, environmental, and healthcare factors. Cancer mortality is higher across multiple age groups in both males and females, with the strongest associations among older adults, males aged 65–74 and females aged 55–64. While our findings cannot establish causality, they highlight the need for further research into potential exposure pathways, latency effects, and cancer-specific risks, emphasizing the importance of addressing these potentially substantial but overlooked risks to public health.

Nuclear power plants have long been a major source of energy production worldwide, playing a critical role in electricity generation. As of 2023, approximately 440 nuclear reactors were operational globally, with a combined capacity of about 390 gigawatts electrical (GWe), generating 2602 terawatt-hours (TWh) of electricity and accounting for approximately 9% of global electricity production. With about 60 additional reactors under construction and over 110 planned, nuclear energy remains an important source. In addition, approximately 30 countries are considering or initiating nuclear power programs (World Nuclear Association (WNA)).

The United States began generating electricity from commercial nuclear power plants in 1958 and is now the world's largest producer of nuclear energy, contributing about 30% of global nuclear electricity. As of August 1, 2023, the U.S. operates 93 commercial nuclear reactors across 54 plants in 28 states, providing a significant portion of the nation's electricity. The average reactor age is approximately 42 years, reflecting the long-term reliance on nuclear energy for power generation (WNA, U.S. Energy Information Administration (EIA)).

Nuclear power plants emit radioactive pollutants that can disperse into the surrounding environment, leading to potential human exposure through inhalation, ingestion, and direct contact. These pollutants can be transported through air, water, and soil, contributing to long-term environmental contamination[1]. Populations residing near nuclear power plants may experience low-level chronic exposure to ionizing radiation via environmental release pathways. While our study does not include dosimetry, ionizing radiation is a well-established

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RESEARCH

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Check for updates

Ionising radiation and cardiovascular disease: systematic review and meta-analysis

Mark P Little,[1] Tamara V Azizova,[2] David B Richardson,[3] Soile Tapio,[4] Marie-Odile Bernier,[5] Michaela Kreuzer,[6] Francis A Cucinotta,[7] Dimitry Bazyka,[8] Vadim Chumak,[8] Victor K Ivanov,[9] Lene H S Veiga,[1] Alicia Livinski,[10] Kossi Abalo,[11,12] Lydia B Zablotska,[13] Andrew J Einstein,[14] Nobuyuki Hamada[15]

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Additional material is published online only. To view please visit the journal online.

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Accepted: 09 February 2023

ABSTRACT

OBJECTIVE

To systematically review and perform a meta-analysis of radiation associated risks of cardiovascular disease in all groups exposed to radiation with individual radiation dose estimates.

DESIGN

Systematic review and meta-analysis.

MAIN OUTCOME MEASURES

Excess relative risk per unit dose (Gy), estimated by restricted maximum likelihood methods.

DATA SOURCES

PubMed and Medline, Embase, Scopus, Web of Science Core collection databases.

ELIGIBILITY CRITERIA FOR SELECTING STUDIES

Databases were searched on 6 October 2022, with no limits on date of publication or language. Animal studies and studies without an abstract were excluded.

RESULTS

The meta-analysis yielded 93 relevant studies. Relative risk per Gy increased for all cardiovascular disease (excess relative risk per Gy of 0.11 (95% confidence interval 0.08 to 0.13)) and for the four major subtypes of cardiovascular disease (ischaemic heart disease, other heart disease, cerebrovascular disease, all other cardiovascular disease). However, interstudy heterogeneity was noted (P<0.05 for all endpoints except for other heart disease), possibly resulting from interstudy variation in unmeasured confounders or effect modifiers, which is markedly reduced if attention is restricted to higher quality studies or those at moderate doses (<0.5 Gy) or low dose rates (<5 mGy/h). For ischaemic heart disease and all cardiovascular disease, risks were larger per unit dose for lower dose (inverse dose effect) and for fractionated exposures (inverse dose fractionation effect). Population based excess absolute risks are estimated for a number of national populations (Canada, England and Wales, France, Germany, Japan, USA) and range from 2.32% per Gy (95% confidence interval 1.68% to 2.96%) for England and Wales to 3.64% per Gy (2.63% to 4.64%) for Germany, largely reflecting the underlying rates of cardiovascular disease mortality in these populations. Estimated risk of mortality from cardiovascular disease are generally dominated by cerebrovascular disease (around 0.94-1.26% per Gy), with the next largest contribution from ischaemic heart disease (around 0.34-1.37% per Gy).

CONCLUSIONS

Results provide evidence supporting a causal association between radiation exposure and cardiovascular disease at high dose, and to a lesser extent at low dose, with some indications of differences in risk between acute and chronic exposures, which require further investigation. The observed heterogeneity complicates a causal interpretation of these findings, although this heterogeneity is much reduced if only higher quality studies or those at moderate doses or low dose rates are considered. Studies are needed to assess in more detail modifications of radiation effect by lifestyle and medical risk factors.

SYSTEMATIC REVIEW REGISTRATION

PROSPERO CRD42020202036

WHAT IS ALREADY KNOWN ON THIS TOPIC

Exposure to high dose ionising radiation during radiotherapy can damage the heart

Cardiovascular disease risk in the low dose range (<0.1 Gy), characteristic of doses that patients receive from medical diagnostic exposures or those radiation workers receive from occupational exposures is not well understood

Previous systematic reviews published over a decade ago looked at a much smaller number of studies, mostly with lower dose or lower dose rate exposures

WHAT THIS STUDY ADDS

A systematic review of 15 098 studies yielded 93 informative and largely non-overlapping studies and suggest modest but significantly increased excess lifetime risk of 2.3-3.9 deaths per 100 people exposed to one Gy of radiation

These findings have implications for patients who undergo radiation exposure as part of their medical care, as well as policy makers involved in managing radiation risks to radiation workers and the public

The potential increased risk of radiogenic cardiovascular disease should prompt vigilance to control other modifiable cardiovascular risk factors and extra consideration of cardiovascular disease following radiation exposure

Introduction

Cardiovascular diseases are the leading cause of death worldwide.[1 2] Cardiovascular disease was the underlying cause of death for about a third of the 2.8 million deaths in the USA in 2018: ischaemic heart disease accounted for 42% and stroke for 17% of all cardiovascular disease deaths.[3] Worldwide, ischaemic heart disease ranks first in years of life lost and stroke ranks third. Consistently identified independent risk factors include age, smoking, diabetes mellitus, hypertension, obesity, and increased total and low density lipoprotein or decreased high density lipoprotein cholesterol.[4-6] A heritable genetic

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Radiation Health Effects

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Article

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proximity to nucl
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Original article

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Scand J Work Environ Health. 2025;51(6):495–504. doi:10.5271/sjweh.4246

Exposure to protracted low-dose ionizing radiation and incident dementia in a cohort of Ontario nuclear power plant workers

by Brianna Frangione, BSc,[1,2] Ian Colman, PhD,[2] Franco Momoli, PhD,[2] Estelle Davesne, PhD,[3] Robert Talarico, MSc,[4] Chengchun Yu, MSc,[4] Paul J Villeneuve, PhD [1]

Frangione B, Colman I, Momoli F, Davesne E, Talarico R, Yu C, Villeneuve PJ. Exposure to protracted low-dose ionizing radiation and incident dementia in a cohort of Ontario nuclear power plant workers. *Scand J Work Environ Health*. 2025;51(6):495–504.

Objectives Emerging evidence suggests that low-dose ionizing radiation increases the risk of neurodegenerative diseases. Past studies have relied on death data to identify dementia, and these are prone to under-ascertainment and complicate the estimation of health risks as individuals tend to live with dementia for many years following onset. We present findings from the first occupational cohort to investigate dementia risk from low-dose radiation using incident outcomes.

Methods This is a retrospective cohort of 60 874 Ontario Nuclear Power Plant workers from the Canadian National Dose Registry. Personal identifiers were linked to Ontario population-based administrative health data. Incident dementias between 1996 and 2022 were identified using a validated algorithm based on physician, hospital, and prescription drug data. Individual-level annual estimates of whole-body external ionizing radiation were derived from personal workplace monitoring. The incidence of dementia among these workers was compared to a random sample of Ontario residents matched by sex, age, and residential area. Internal cohort analysis using Poisson and linear excess relative risk (ERR) models, adjusted for sex, attained age, calendar period, and neighborhood income quintile, were used to characterize the shape of the exposure-response curve between low-dose cumulative radiation (lagged 10 years) and incident dementia.

Results There were 476 incident dementias and 867 028 person-years of follow-up. The mean whole-body lifetime accumulated exposure at the end of follow-up was 11.7 millisieverts (mSv). Workers with cumulative exposure between 50–100 mSv had an increased risk of dementia [RR 1.50, 95% confidence interval (CI) 0.99–2.28] compared to those unexposed. Spline analysis suggested that the dose–response relationship was non-linear. The linear ERR per 100 mSv increase in exposure was 0.704 (95% CI 0.018–1.390).

Conclusion Our findings suggest that low-dose exposure to ionizing radiation increases the risk of incident dementia.

Key terms Canada; dementia incidence; occupational health; radiation risk.

There is an important need to understand the health effects of ionizing radiation, as exposure, to some degree, is ubiquitous. Millions worldwide are employed in occupations where exposures are several orders of magnitude higher than background levels, highlighting the importance of assessing and mitigating potential health risks (1). Studies on these workers can help inform risks not only in occupational settings, but also in the general population. Indeed, exposure to low-dose ionizing radiation [cumulative doses <100 millisieverts (mSv)] has been the focus of a number of occupational cohorts (2). Several studies have been conducted on workers exposed to chronic low-dose radiation in the nuclear industry, but almost all studies have assessed the effects on cancer incidence and mortality (2). There is emerging evidence of other adverse health effects of low-dose ionizing radiation, including cardiovascular diseases (3), adverse birth outcomes (4), glaucoma (5), and cataracts (6).

Recent work has implicated ionizing radiation as a risk factor for neurodegenerative diseases, such as dementia (7). There are several possible pathways

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RESEARCH

lar disease: systematic review

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k factors.
C REVIEW REGISTRATION
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lar diseases are the leading cause of
wide.[1,2] Cardiovascular disease was the
ause of death for about a third of the
deaths in the USA in 2018: ischaemic
accounted for 42% and stroke for 17%
vascular disease deaths.[3] Worldwide,
art disease ranks first in years of life
ke ranks third. Consistently identified
risk factors include age, smoking,
us, hypertension, obesity, and increased
density lipoprotein or decreased high
tein cholesterol.[4-6] A heritable genetic

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Business / Energy

Brent crude oil price spikes to $109.1 amid Iran-US-Israel war

Geopolitical unrest drives Brent crude to highest in years

Last updated: March 09, 2026 | 03:26

Jay Hilotin, *Senior Assistant Editor*

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Brent crude o
amid Iran-US

Geopolitical unrest drives B

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Brent Falls Below $90 as Trump Signals War May End

By Josh Owens - Mar 08, 2026, 9:37 PM CDT

Updated: Mar 09, 2026, 5:29 PM CDT

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Brent crude amid Iran-U

Geopolitical unrest drive

Last updated: March 09, 2026 |

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POLITICO

US official: 'Not true' Navy successfully escorted oil tanker through Strait of Hormuz

Energy Secretary Chris Wright claimed in a now-deleted social media post that the Navy escorted an oil tanker through the Strait of Hormuz.

Energy Secretary Chris Wright (left) and Rep. Gabe Evans (R-Colo.) speak at the Fort St. Vrain Generating Station in Platteville, Colorado. | Jason Plautz/POLITICO's E&E News

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90 as Trump

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2025 BREAKTHROUGH OF THE YEAR

GOOD MORNING, SUNSHINE

The seemingly unstoppable growth of renewable energy is *Science*'s 2025 Breakthrough of the Year

BY TIM APPENZELLER

Since the Industrial Revolution, human society has run on ancient solar energy—captured by plants hundreds of millions of years ago, stored in fossil fuels, and dug and drilled from the earth. But this year momentum shifted unmistakably toward the energy that streams from the Sun today. Renewable energy, most of it from sunlight itself or from wind, ultimately driven by the Sun, overtook conventional energy on multiple fronts.

This year, renewables surpassed coal as a source of electricity worldwide, and solar and wind energy grew fast enough to cover the entire increase in global electricity use from January to June, according to energy think tank Ember

The Trajectory of the Energy Transition – in Japan and the World

Tomas Kåberger
Executive Board Chair of Renewable Energy Institute, Tokyo
Professor, Director of Energy Area of Advance, Chalmers University of Technology
Fellow of the Swedish Royal Academy of Engineering Sciences