Impacts of materials and their supply chains

Part 3 – end of life and to NetZero

Dr. Martyn Wakeman

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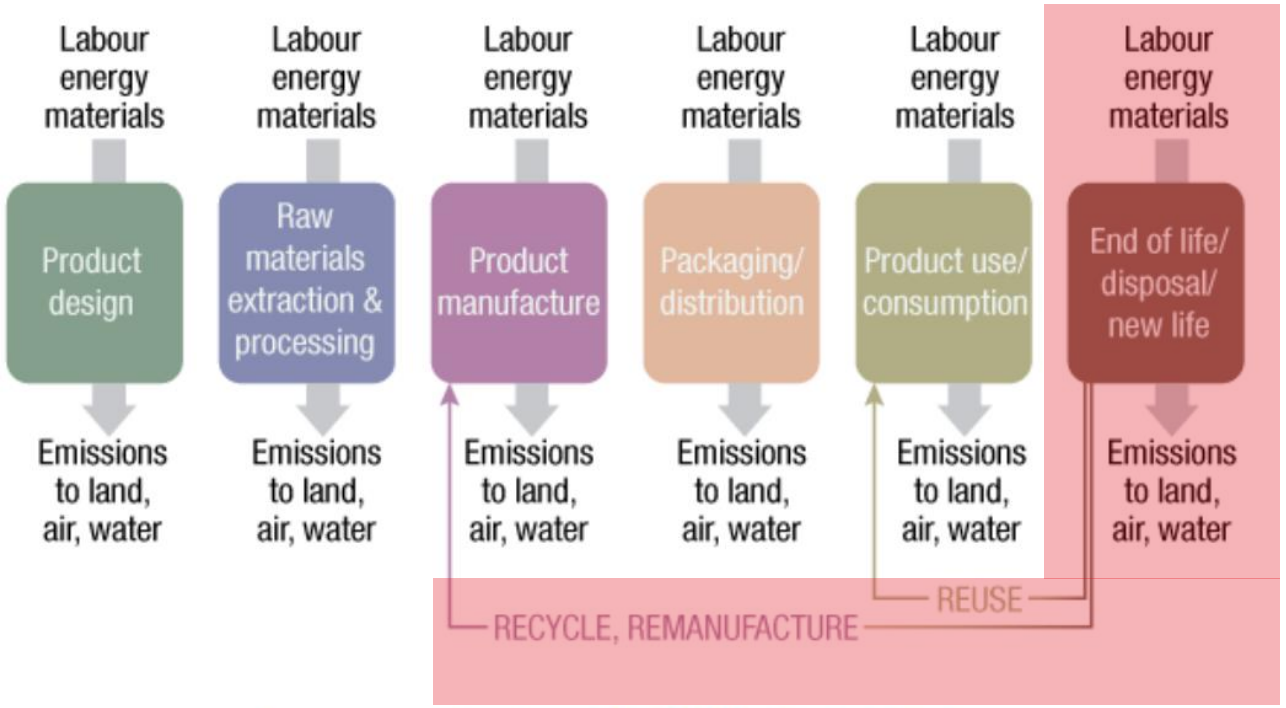
Overview

- The value of nature
- Raw material extraction & transformation
- Use phase
- End of life
- 2020 Petro-chemical economy vs. 2050 NetZero

End of life & disposal

Figure 1: Phases in the life cycle of a product. Life Cycle Assessment (LCA) is a quantitative tool that facilitates the systematic quantitative assessment of products, in terms of environmental, human health, and resource consumption considerations. The methodology is internationally standardised by ISO 14040.

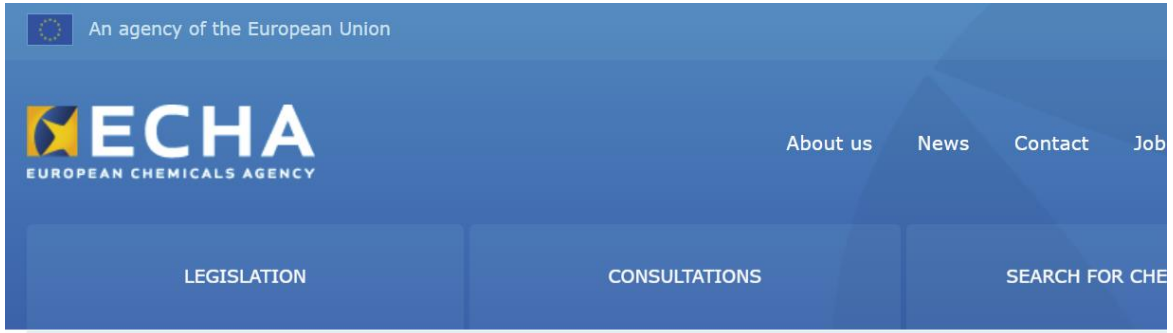


Source: Modified from UNEP Life Cycle Initiative.

RMIS - Environmental impacts along the supply chain

End-of-Life Treatment Overview

- Refers to the disposal or recycling of products after use.
- Options
  - Landfilling
  - Incineration
  - Recycling
  - (also be reused or repurposed to reduce waste and resource demand)
- The environmental impacts of disposal methods vary significantly.
- Efforts to improve recycling rates and reduce landfill use are ongoing.



ECHA raises environmental concerns over certain aromatic brominated flame retardants

18/12/2024 | REACH

The European Chemicals Agency's (ECHA) investigation found that use of non-polymeric aromatic brominated flame-retardant additives pollutes the environment due to their persistence, bioaccumulation and toxicity. These substances are released to the environment throughout the product lifecycle, with waste stage being of particular concern.

Homepage - ECHA

Impacts of Landfills

- **Environment**
  - Landfills can produce methane, a potent greenhouse gas.
  - Leachate from landfills can contaminate local groundwater supplies.
  - Landfills consume large areas of land, often in ecologically sensitive zones.
  - The decomposition of waste contributes to soil and air pollution.
  - Decreasing landfill space is a growing concern due to urbanization.
- **Societal**
  - Communities near landfills may experience reduced property values.
  - Health risks to local populations from exposure to leachate and air pollutants.
  - Social conflicts arise when landfills are sited near low-income or marginalized communities.
  - Negative aesthetic impacts, including odor and visual pollution.
- **Human**
  - Exposure to toxic substances, including heavy metals and VOCs (volatile organic compounds).
  - Respiratory issues due to particulate matter and methane in the air.
  - Waterborne diseases from contaminated water sources.
  - Risk of cancer from long-term exposure to landfill chemicals.
  - The health burden disproportionately affects vulnerable populations.

Landfill Site In Leicestershire Photograph by Science Photo Library - Pixels

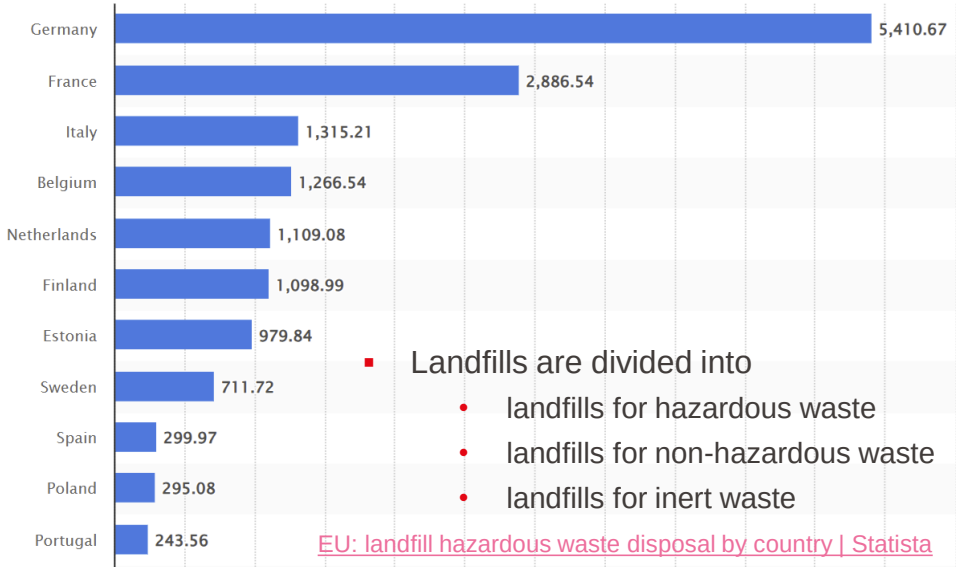
EU waste legislation

Waste Framework Directive lays down some basic waste management principles.

- It requires that waste be managed
  - without endangering human health and harming the environment
  - without risk to water, air, soil, plants or animals
  - without causing a nuisance through noise or odours
  - without adversely affecting the countryside or places of special interest
- It explains when waste ceases to be waste and becomes a secondary raw material, and how to distinguish between waste and by-products.
- The Directive also introduces the "polluter pays principle" and the "extended producer responsibility".
- It establishes an order of preference for managing and disposing of waste.
- Landfilling is almost non-existent in countries such as Belgium, the Netherlands, Denmark, Sweden, Germany, Austria, Luxemburg, Slovenia and Finland. Here incineration plays an important role alongside recycling.

Landfill Directive sets out strict operational requirements for landfill sites with the objective to protect both human health and the environment.

- To support the EU's transition to the circular economy, introduces restrictions on landfilling of all waste that is suitable for recycling or other material or energy recovery from 2030
- Limits the share of municipal waste landfilled from 18% in 2020 to 10% by 2035
- Requires EU countries to put in place an effective quality control and traceability system for municipal waste landfilled

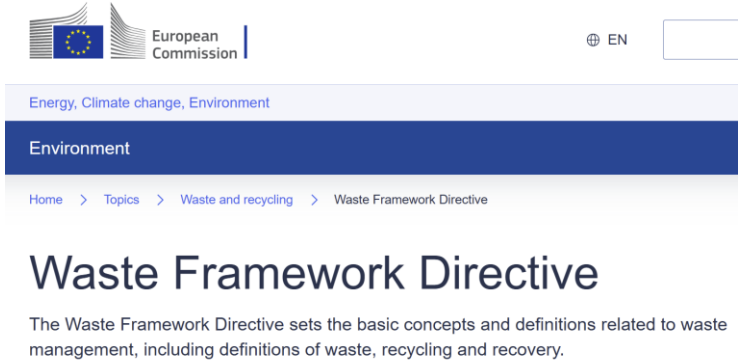


Deposits of hazardous waste onto and in landfills in the European Union (EU-27) in 2020, by country

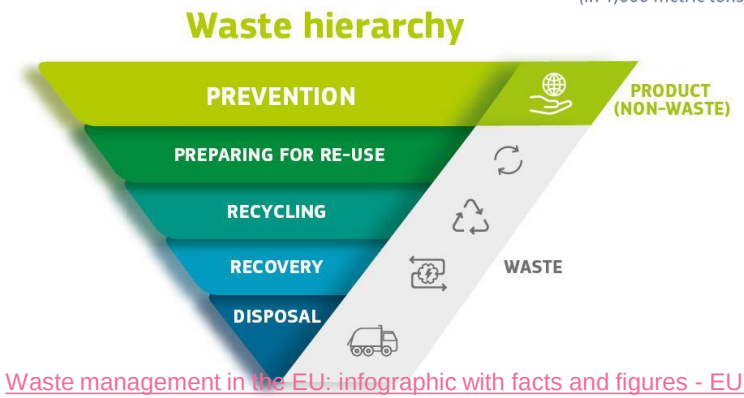
(in 1,000 metric tons)

EU: landfill hazardous waste disposal by country | Statista

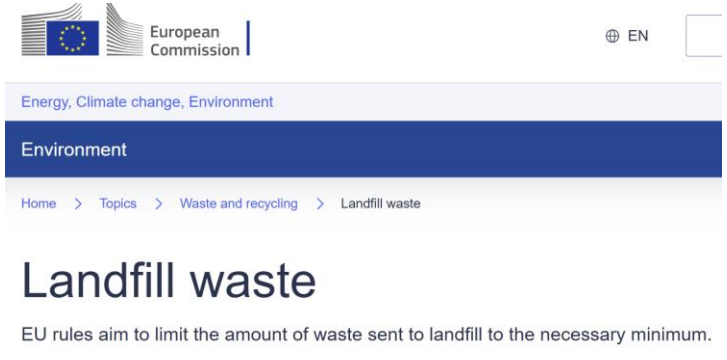
- Landfills are divided into
  - landfills for hazardous waste
  - landfills for non-hazardous waste
  - landfills for inert waste



Waste Framework Directive - European Commission



Waste management in the EU: infographic with facts and figures - EU monitor



Landfill waste - European Commission

EU waste

Export of waste outside the EU

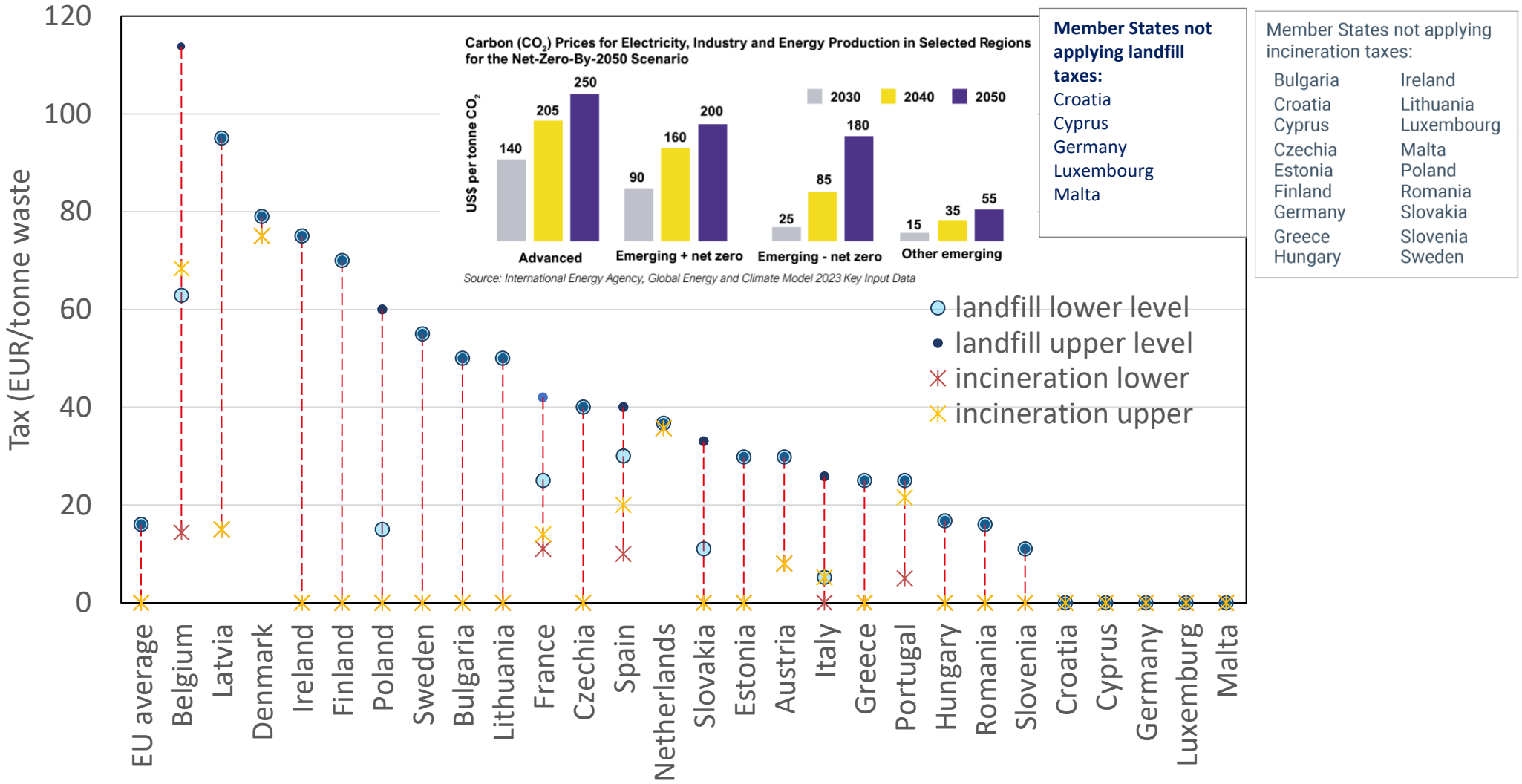
- 2021, EU exports of waste to non-EU countries reached 33 million tonnes, increase of 77% compared to 2004.
- Ferrous and non-ferrous metal scrap, paper, plastic, textile and glass wastes.
- EU exports of ferrous metal scrap and glass waste go mostly to OECD member countries, while those of non-ferrous scrap, paper waste, plastic waste and textile waste mostly go to non-OECD member countries.
- In 2021, 45% EU waste went to: Turkey (14.7 MT), followed by India (2.4 MT), Egypt (1.9 MT), Switzerland (1.7 MT) and the UK (1.5 MT).
- EU wants to counter illegal exports and ensure waste is managed in an environmentally sound manner in the destination countries.

Parliament's work to achieve a circular economy

- October 2022, revision of the rules on persistent organic pollutants to reduce the amount of dangerous chemicals in waste and production processes.
- The new rules will introduce stricter limits, ban certain chemicals and keep pollutants away from recycling.
- In February 2021, the Parliament adopted a resolution on the new circular economy action plan demanding additional measures to achieve a carbon-neutral, environmentally sustainable, toxic-free and fully circular economy by 2050, including tighter recycling rules and binding targets for materials use and consumption by 2030.
- In November 2022, the European Commission proposed new EU-wide rules on packaging. It includes proposals to improve packaging design, such as clear labelling, to promote reuse and recycling and calls for a transition to bio-based, biodegradable, and compostable plastics.

Waste management in the EU: infographic with facts and figures - EU monitor

Landfill versus incineration: tax needs increasing?



Member States not applying landfill taxes:
Croatia
Cyprus
Germany
Luxembourg
Malta

Member States not applying incineration taxes:

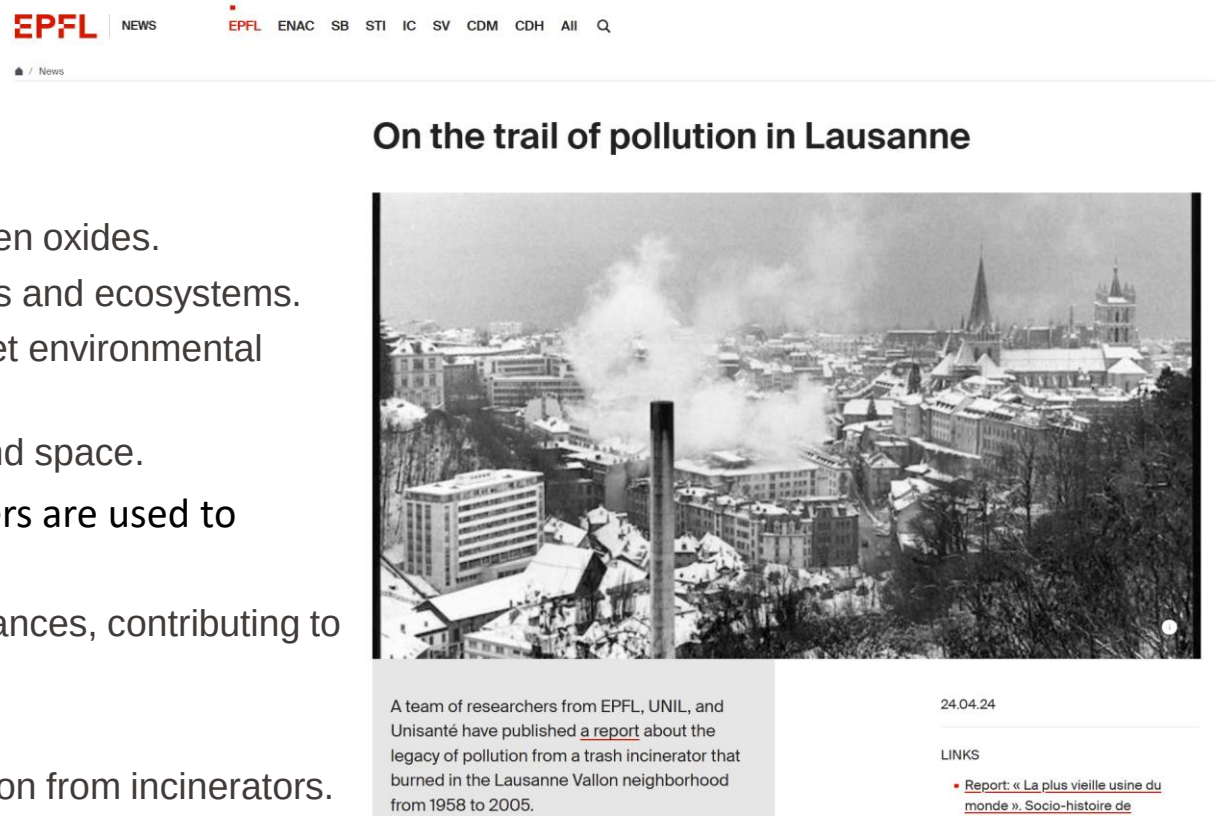
Bulgaria	Ireland
Croatia	Lithuania
Cyprus	Luxembourg
Czechia	Malta
Estonia	Poland
Finland	Romania
Germany	Slovakia
Greece	Slovenia
Hungary	Sweden

Overview of taxes on the incineration of municipal waste used in EU Member States, 2023 | European Environment Agency's home page

Overview of landfill taxes on municipal waste used in EU Member States, 2023 | European Environment Agency's home page

Incineration

- **Environmental**
  - Emits carbon dioxide and other air pollutants like nitrogen oxides.
  - Can release dioxins and furans, harmful to both humans and ecosystems.
  - Energy recovery from waste incineration reduces the net environmental impact but CO2e released
  - Incineration facilities require significant infrastructure and space.
  - Emission control technologies like scrubbers and filters are used to reduce harmful air pollutants.
  - Ash produced in incinerators often contains toxic substances, contributing to soil pollution.
- **Societal**
  - Local communities may suffer from air and noise pollution from incinerators.
  - The incineration of waste can reduce the volume of landfill waste but is controversial.
  - Public resistance to incineration often comes from NIMBY (Not In My Backyard) sentiments.
- **Human**
  - Respiratory problems from inhalation of toxins released in the air.
  - Increased cancer risks due to prolonged exposure to incineration byproducts.
  - Birth defects and developmental issues linked to air pollution and dioxins.
  - Potential for contamination of local water supplies from airborne pollutants

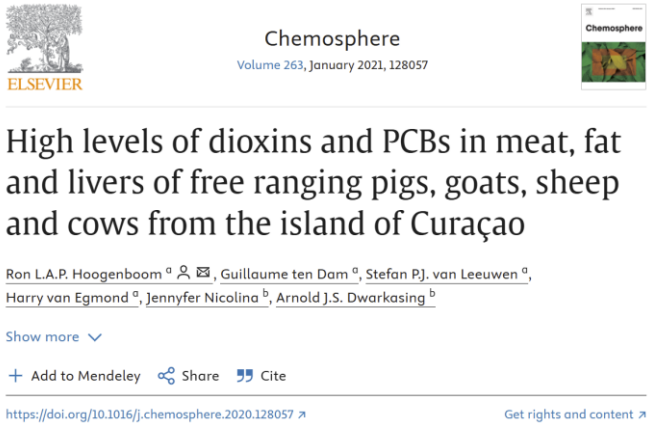


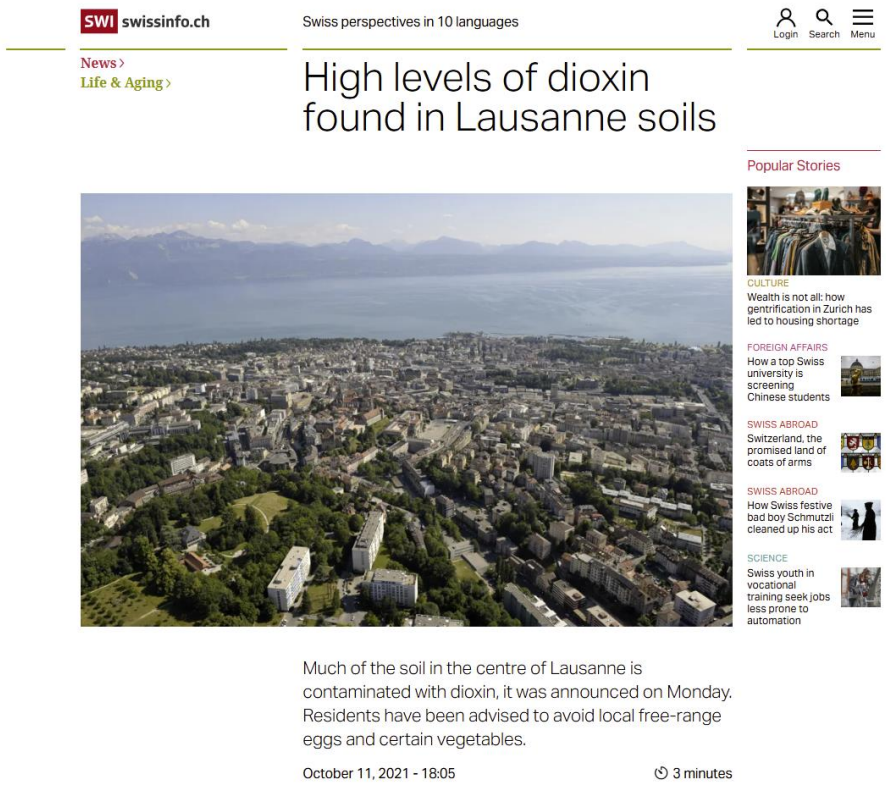
At the end of 2020, dioxins and furans were discovered in the soil of Lausanne's Vallon neighborhood

On the trail of pollution in Lausanne - EPFL

Dioxins, food, and human health

- Mainly by-products of industrial processes, also from volcanic eruptions and forest fires.
- Unwanted by-products of many manufacturing processes including smelting, chlorine bleaching of paper pulp and the manufacture of some herbicides and pesticides.
- Uncontrolled waste incinerators (solid waste and hospital waste) are often the worst culprits of environmental release due to incomplete burning.
- Technology is available that allows for controlled waste incineration with low dioxin emissions.
- Although formation of dioxins is local, environmental distribution is global.
- Lipid based levels in fat and meat were in general comparable.
- Lipid based liver levels were much higher, pigs being most sensitive.
- Patterns point to burning as the major source, but also PCBs contribute.





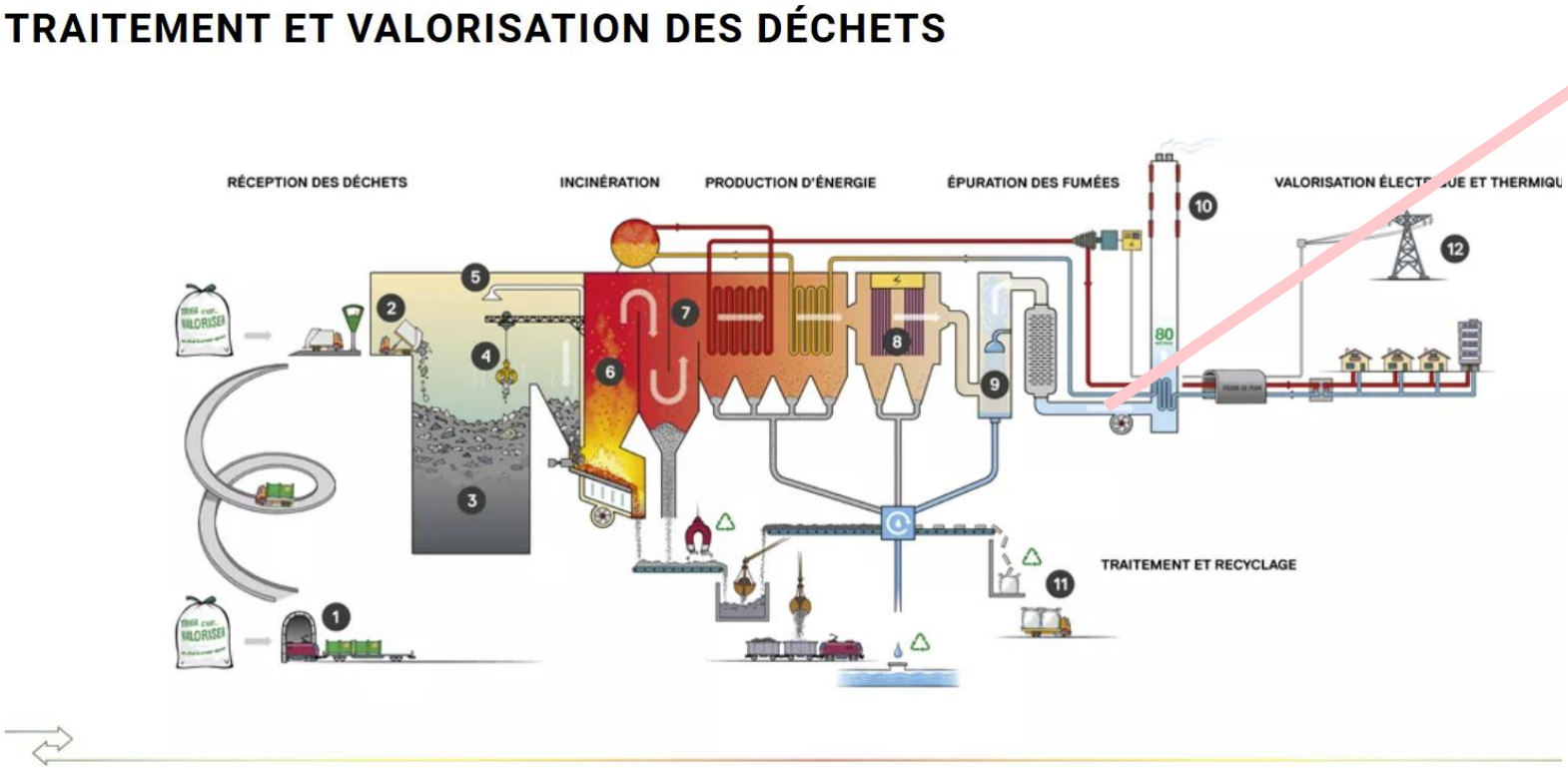
High levels of dioxin found in Lausanne soils - SWI swissinfo.ch

High levels of dioxins and PCBs in meat, fat and livers of free ranging pigs, goats, sheep and cows from the island of Curaçao - ScienceDirect

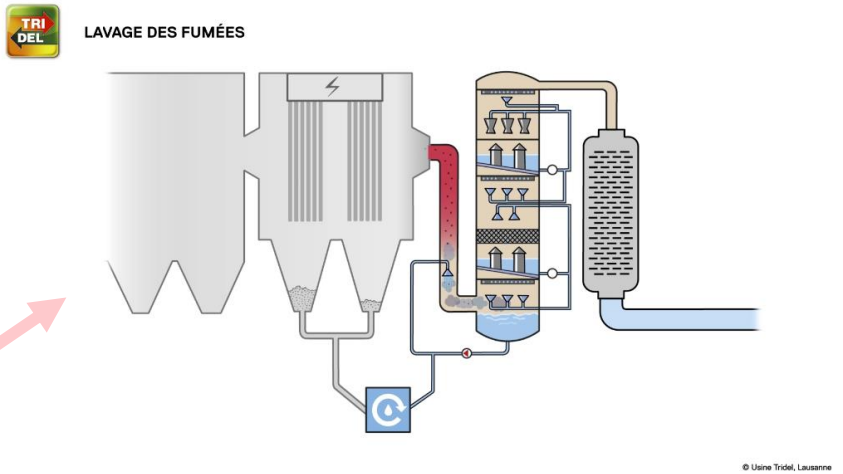
Dioxins

Intake of dioxins and related compounds from food in the U.S. population - PubMed

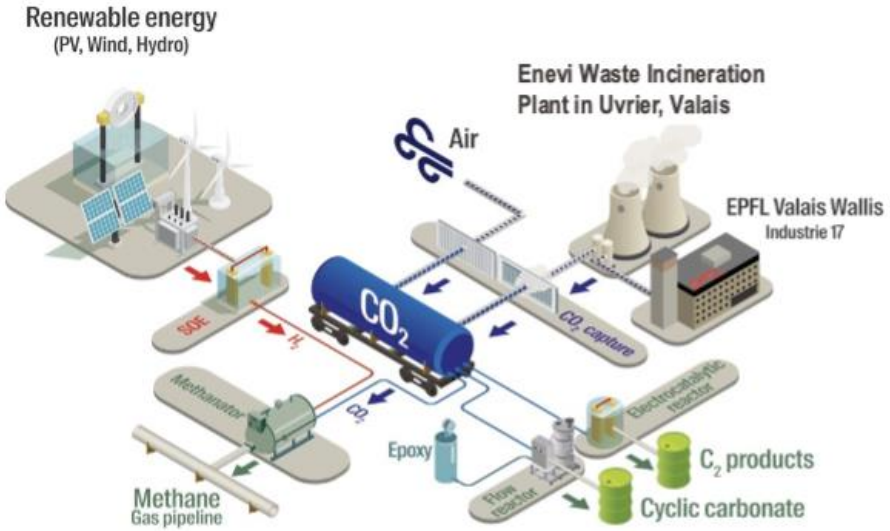
Incineration: Switzerland



Tridel



- Now state of the art with scrubbing of fumes but still releases CO2e



SusEcoCCUS – Research - EPFL

Micro-plastics

- Small plastic particles less than 5 mm in size
- Infiltrated virtually every corner of the Earth, from depths of oceans to air we breathe
- As MPs infiltrate the environment, they can enter the food chain
- Research on the immune system's response to MPs is still in its infancy
- Growing evidence that MPs exposure can trigger immune responses in animals
- MPs containing harmful chemicals (additives) coming into contact with our bodies.
- These additives may be discharged from packaging of food items, medical devices, rubber and tyre burning, atmospheric and dust particulate matters, cosmetics, daily used toothbrushes, hand wash.
- This can include heavy metals, BPA, phthalates, and polychlorinated biphenyls (PCBs)
- Identified as endocrine disruptors

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Environmental Toxicology and Pharmacology

Volume 104, November 2023, 104324

Microplastics and their environmental effects

Paolo Pastorino [a], Damià Barceló [b]

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Microplastics and their environmental effects - ScienceDirect

Microplastics: Their effects on the environment, human health, and plant ecosystems - ScienceDirect

What Endocrine Disruptors Are and How to Avoid Them

KeAi
CHINESE ROOTS GLOBAL IMPACT

Environmental Pollution and Management

Volume 1, October 2024, Pages 248-259

Microplastics: Their effects on the environment, human health, and plant ecosystems

Pachuau Lalrinfela [a], Rebecca Vanlalsangi [a], Khawlhring Lalrinzuali [b], Punuri Jayasekhar Babu [c]

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Bioaccumulation of microplastics in decedent human brains

nature medicine

Brief Communication https://doi.org/10.1038/s41591-024-03453-1

Bioaccumulation of microplastics in decedent human brains

Received: 29 April 2024

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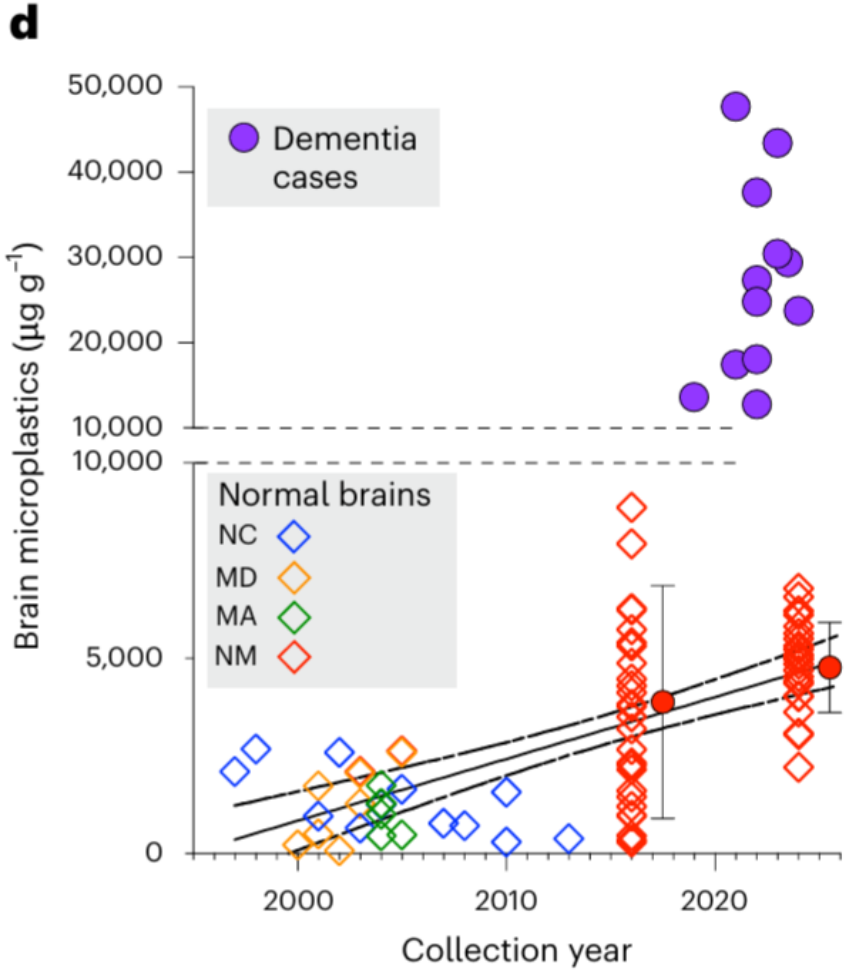
Check for updates

Alexander J. Nihart[1,12], Marcus A. Garcia[1,12], Eliane El Hayek[1,12], Rui Liu[1], Marian Olewine[1], Josiah D. Kingston[1], Eliseo F. Castillo[2], Rama R. Gullapalli[3], Tamara Howard[4], Barry Bleske[5], Justin Scott[6], Jorge Gonzalez-Estrella[6], Jessica M. Gross[7], Michael Spilde[8], Natalie L. Adolphi[8], Daniel F. Gallego[9], Heather S. Jarrell[9], Gabrielle Dvorscak[9], Maria E. Zuluaga-Ruiz[10], Andrew B. West[11] & Matthew J. Campen[1]

UNM Researchers Find Alarmingly High Levels of Microplastics in Human Brains – and Concentrations are Growing Over Time

University of New Mexico Health Sciences researchers have detected microplastics in human brains at much higher concentrations than in other organs – and the plastic accumulation appears to be growing over time, having increased 50% over just the past eight years.



Cannot say if microplastics are causative to dementia or if brains with dementia accumulate more due to morphology

MSE-433

UNM Researchers Find Alarmingly High Levels of Microplastics in Human Brains – and Concentrations are Growing Over Time

Bio-accumulation-microplastics-human-brain.pdf

Microplastics and LCA

- Incorporating microplastics into LCA is challenging due to lack of inventory data.
- LCA requires thorough risk assessment to develop characterization factors.
- The environmental impacts of microplastics are not often reported by LCAs.
- LCAs often overlook long-term impacts of plastic waste (>100 years).
- Microplastic production during product usage commonly oversimplified.

ELSEVIER

Science of The Total Environment

Volume 954, 1 December 2024, 176513

Review

The missing link: A systematic review of microplastics and its neglected role in life-cycle assessment

Tu Xayachak [a], Nawshad Haque [b], Deborah Lau [c], Biplob Kumar Pramanik [a]

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The missing link: A systematic review of microplastics and its neglected role in life-cycle assessment - ScienceDirect

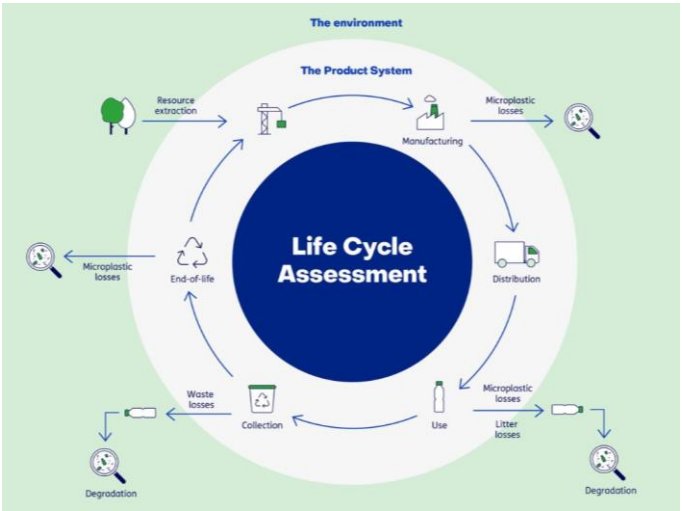
New method also considers environmental impact of microplastics

Microplastics 21 August 2024

Due to the increase in the use of plastics, the formation of microplastics in the environment is rising. However, the impact of these tiny plastic particles is not yet included in environmental and sustainability analyses. TNO is changing this, using a new method. The new method calculates in a life cycle analysis how many microplastics are released during the production, use, and disposal of a specific type of plastic. Anna Schwarz, one of the lead researchers, explains how this method works and what the implications are for future environmental analyses.

New method for environmental impact of microplastics

A plastic container enters the environment faster than a glass jar and therefore has an effect on the environment. Because that factor is currently not included, the comparison is actually not quite fair.
We've therefore developed a new method that does include this impact of microplastics in the LCA of plastic products. This brings us one step closer to gaining a full picture of the impact of plastic products.'



Microplastics in the EU

In the EU

30% by 2030

EU target to reduce microplastics released into the environment

Between 200 and 600

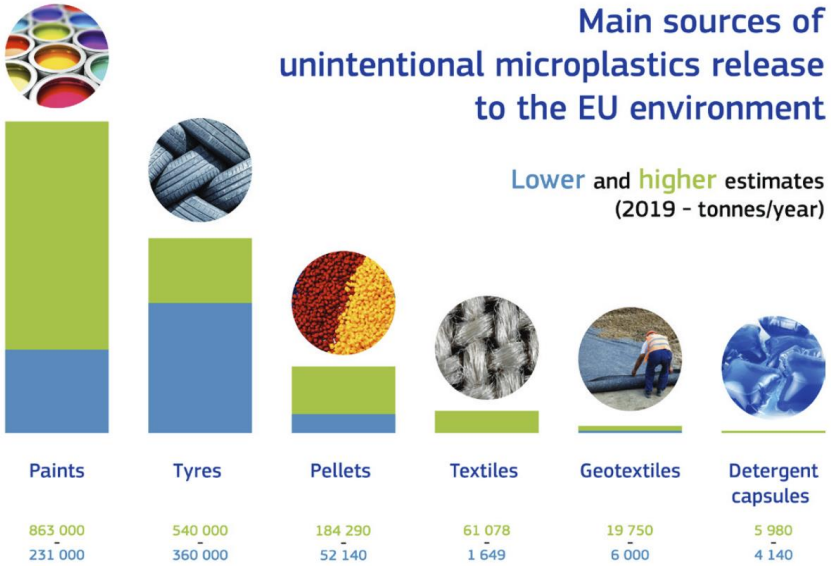
olympic size swimming pools of microplastics are unintentionally released into the environment every year

Over 2100 truckloads

of plastic pellets were lost to the environment in 2019

Main sources of unintentional microplastics release to the EU environment

Lower and higher estimates (2019 - tonnes/year)



EU action against microplastics

Plastic leakage is expected to double

EU action against microplastics - Publications Office of the EU

Microplastics - European Commission

Ocean plastics

- Plastic waste is a significant source of marine pollution, impacting biodiversity.
- Ocean plastics threaten marine life through ingestion, entanglement, and habitat destruction.
- The environmental costs of plastic production and disposal are immense.
- Efforts to reduce plastic use and promote alternatives are gaining traction globally.
- International policies, like the Plastic Waste Treaty, aim to reduce plastic waste entering the oceans.

BBC

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Visualising the Great Pacific Garbage Patch

16 January 2024

Share Save

Frankie Adkins

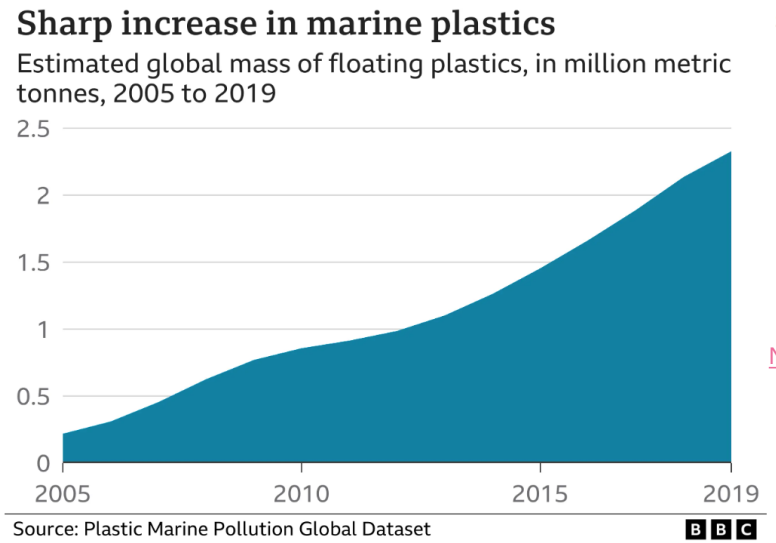
The scale of the GPGP is so great, it is often imagined as a landmass, almost sturdy enough to walk across (Credit: Shutterstock)

Georgina Rannard
BBC Climate and science reporter

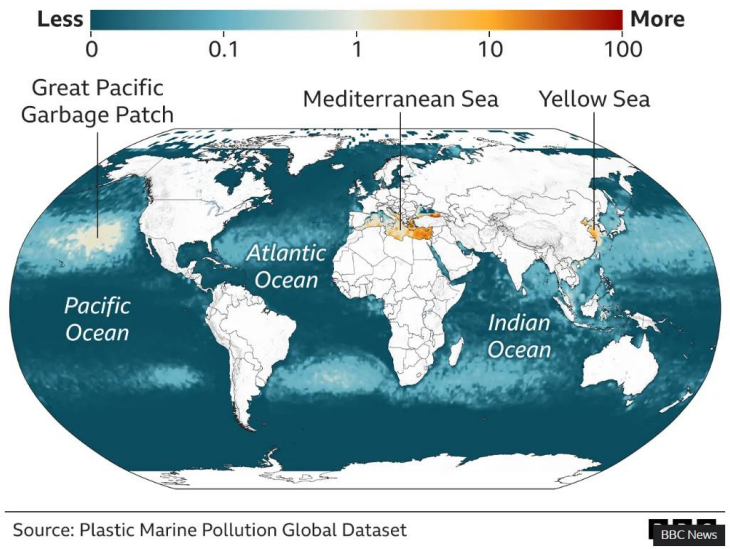
More than 171 trillion pieces of plastic are now estimated to be floating in the world's oceans, according to scientists.

Visualising the Great Pacific Garbage Patch

Ocean plastics



Visualising the Great Pacific Garbage Patch



PLASTICS

New study: Plastic pollution worsens the impacts of all planetary boundaries

New study: Plastic pollution worsens the impacts of all planetary boundaries - Stockholm Resilience Centre

Aerial survey shows the 'Great Pacific Garbage Patch' is much larger than we thought

Hazardous waste

- Hazardous Waste Challenges in Greater China | Wilson Center
- Industrially contaminated sites (who.int)
- Russia Grapples with Long-Abandoned Toxic Waste Sites - The Moscow Times
- The presence of Superfund sites as a determinant of life expectancy in the United States | Nature Communications
- Superfund Sites: 1,317 US Spots Where Toxic Waste Was Dumped | TIME
- Comment: Rather than offsets, companies should repay their debt to nature through a centralized biodiversity fund | Reuters

The Beloye Morye sludge dump, a chemical waste landfill near the former Khimprom plant in Volgograd.Navalny's staff in Volgograd (CC-BY 3.0)

Wakeman

HEALTH • RESEARCH

Do You Live Near Toxic Waste? See 1,317 of the Most Polluted Spots in the U.S.

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Article | Open access | Published: 13 April 2021

The presence of Superfund sites as a determinant of life expectancy in the United States

Amin Kiaghadi, Hanadi S. Rifai & Clint N. Dawson

Nature Communications **12**, Article number: 1947 (2021) | Cite this article

19k Accesses | **25** Citations | **266** Altmetric | Metrics

EPA: Coakley Landfill has ‘unacceptable added risk’ from PFAS

New Hampshire Public Radio | By Claire Sullivan - New Hampshire Bulletin
Published October 7, 2024 at 4:57 PM EDT

Jason Moon / NHPR

Coakley Landfill superfund site sign warning of possible contaminants. NHPR file photo.

EPA: Coakley Landfill has ‘unacceptable added risk’ from PFAS | New Hampshire Public Radio

Overview

- The value of nature
- Raw material extraction & transformation
- Use phase
- End of life
- 2020 Petro-chemical economy vs. 2050 NetZero

Petro-chemical economy vs. 2050 NetZero

2020 Petrochemical Economy

- **GHG emissions**
  - 35% of global CO_2 emissions stemmed from petrochemicals and fossil fuels (IEA, 2020).
- **Plastic pollution**
  - Over 300 million tons of plastic waste annually; 8 million tons enter oceans (WWF, 2020).
- **Land degradation**
  - Oil extraction responsible for deforestation and soil contamination.
- **Water pollution**
  - 30% of industrial water pollution attributed to petrochemicals (UNEP, 2020).
- **Biodiversity loss**
  - Habitat destruction and toxicity impact 60% of threatened species (IPBES, 2020).
- **Yet still increasing life expectancy but wealth disparity growing**

2050 NetZero Economy anticipated benefits (we need to choose this SSP)

- **Emissions reduction**
  - Carbon neutrality with a significant drop in GHG emissions from industrial sectors
- **Renewable energy**
  - 70% of global energy from solar, wind, and hydro sources.
- **Circular economy**
  - 65% circular plastics, near 100% lithium
- **Ecosystem restoration**
  - Reforestation initiatives and cleaner water systems boost biodiversity.
- **Sustainable agriculture**
  - Reduction of nitrogen pollution with organic farming practices.
- **Sustainable mining is key**
- Further benefits to human health and life quality, just and equitable transition critical (SDGs)

EV growth needs mining expansion

- McKinsey: “Mining is currently responsible for 4 to 7 percent of greenhouse-gas (GHG) emissions globally.”
- 28% of global emissions considered Scope 3 (indirect), incl. coal.

yahoo!finance

Climate change: Investment in mining 'needs to nearly double' to achieve net zero, BofA says

CLEAN TECH

Elon Musk says Tesla may have to get into the lithium business because costs are so ‘insane’

Elon Musk: Telsa may have get into mining, refining lithium directly (cnbc.com)

The only long-term solution to ease the supply crunch is to drive investment in the mundane mining and processing technology for lithium in a sustainable and environmentally friendly way. It

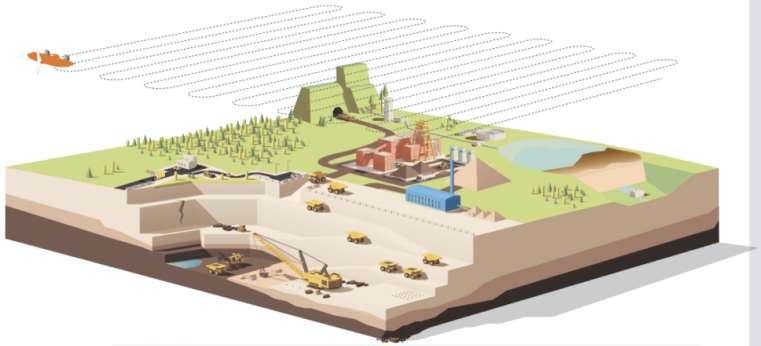
It requires capital, technology and time

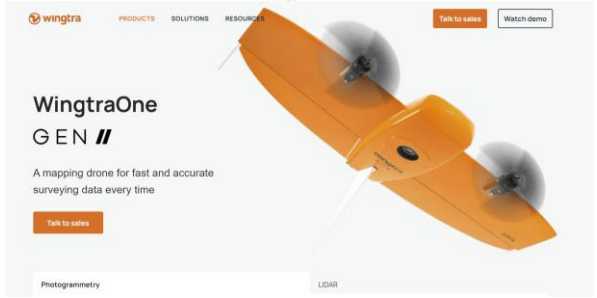
Climate risk and decarbonization: What every mining CEO needs to know | McKinsey

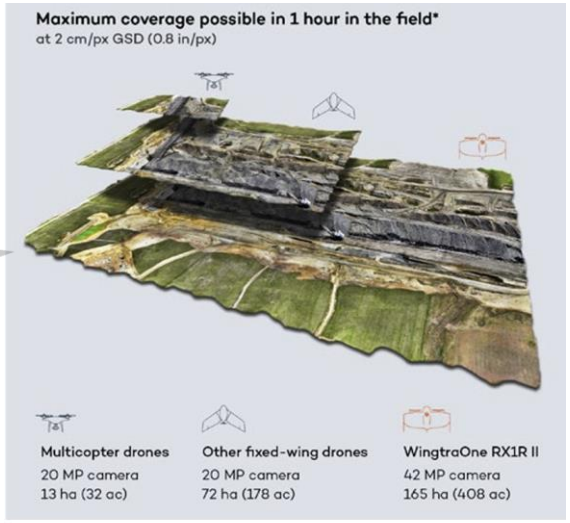
Elon Musk Misses the Big Picture on Lithium Mining - Bloomberg

Green Chemistry and Sustainable Mining

- Green mining technologies, cleaner extraction and renewable energy sources, reduce the carbon footprint of mining.
- Green chemistry to minimize toxic waste production and reduce the environmental impact of chemical processes
- In-situ leaching reduce the need for traditional mining methods, minimizing environmental disruption.
- Techniques like bioleaching and phytoremediation use biological processes to extract minerals with less harm.
- Encouraging the adoption of sustainable mining practices to reduce both ecological and social impacts.
- Technologies such as data analytics, AI, automation and drones, can reduce human labor and increase efficiency.
- Technologies to rehabilitate mining sites, such as land reclamation and habitat restoration.







*Field time includes setup and changing batteries. This data was generated using Wingtra's coverage and labor cost calculator. The calculator estimates the field time and labor costs associated with data collection, using a model based on the technical specifications of each drone under common environmental conditions and flight parameters.

AutoMine® Concept Underground Drill_Amelia

AutoMine® Core

Drone for fast and accurate survey data every time

Geolocation of extraction

Remote Sensing of Environment
Volume 302, 1 March 2024, 113954

Monitoring global cement plants from space

Yuyu Yang [a], Yongxue Liu [a b] ✉, Lei Liu [c d] ✉, Zhuqing Liu [a], Huansha Wu [a]

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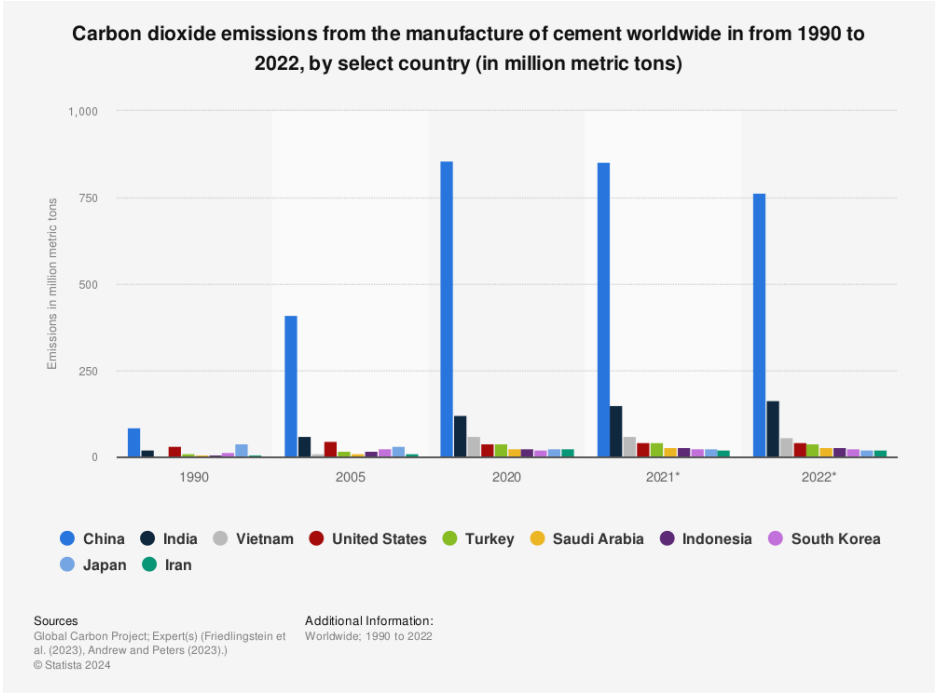
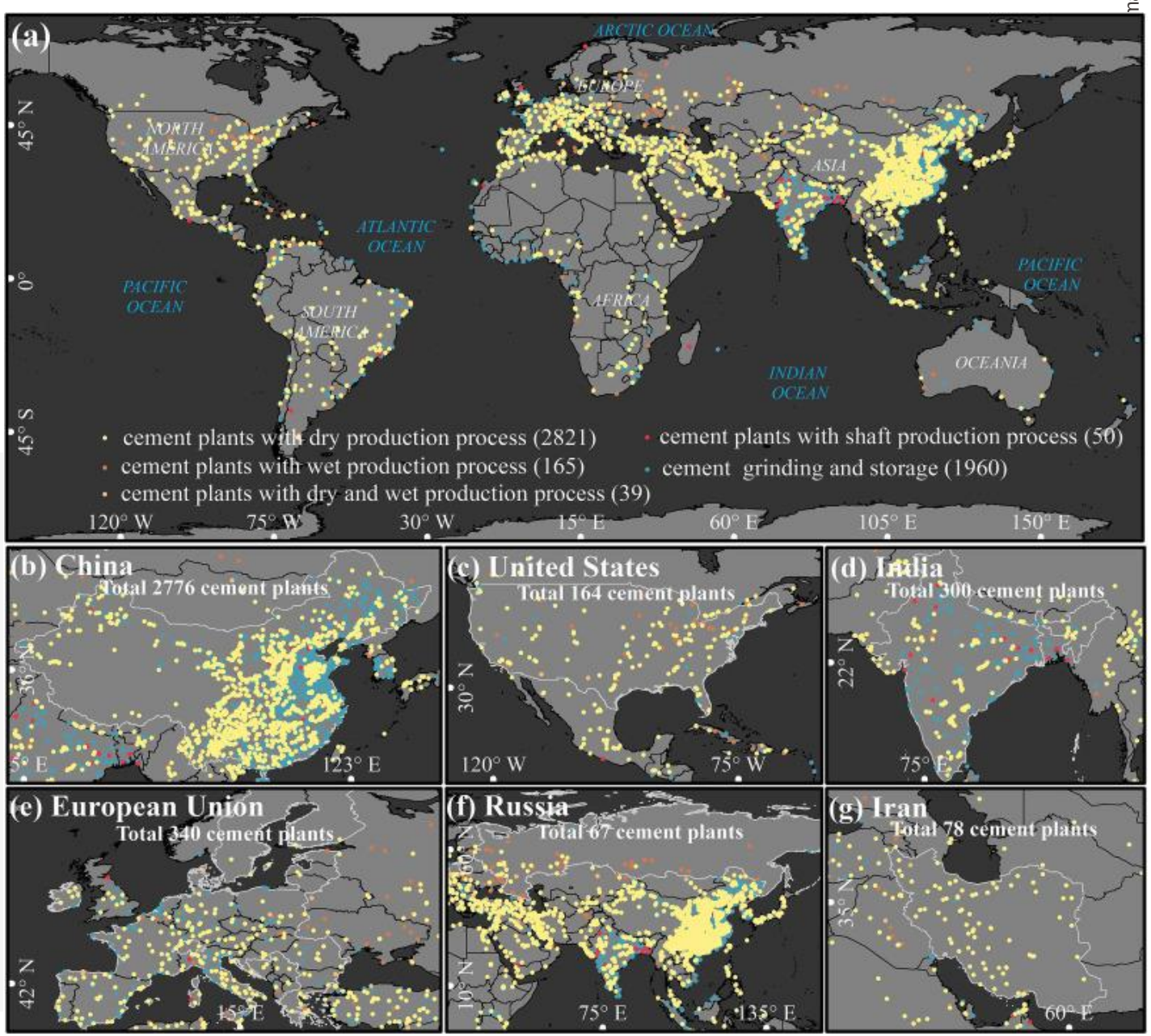




Net Zero CO2 emissions from the industrial sector?

"Are possible but challenging (high confidence) .

- Energy efficiency will continue to be important.
- Reduced materials demand, material efficiency, and circular economy solutions can reduce the need for primary production.
- Primary production options include
  - Switching to new processes that use low to zero GHG energy carriers and feedstocks (e.g., electricity, hydrogen, biofuels, and CCU for carbon feedstock),
  - Carbon capture and storage (CCS) for remaining CO2.
  - Require substantial scaling up of electricity, hydrogen, recycling, CO2, and other infrastructure
  - Phase-out or conversion of existing industrial plants.
- *While improvements in the GHG intensities of major basic materials have nearly stagnated over the last 30 years, analysis of historical technology shifts and newly available technologies indicate these intensities can be reduced to net zero emissions by mid-century."*

IPCC Sixth Assessment Report

Working Group III: Mitigation of Climate Change

Chapter 11: Industry

Chapter 11: Industry

Climate change and road transport

- The significant impact on climate stemming from the fuel that powers our cars is well-known but … **the impact of manufacturing them is often overlooked.**

- **Producing steel, plastics, glass, aluminum, rubber, paints, & other components for vehicles is very carbon intensive.**
- **Largest 12 automotive manufacturers globally generate more greenhouse gases/yr than the entire EU.**
- **Electrifying transport can solve part of the problem - it will halve the emissions from vehicles on average.**
- **But to solve the remaining half, it's key to transition to a circular economy for cars.**

Climate change and a circular economy for transport (ellenmacarthurfoundation.org)

https://www.europarl.europa.eu/news/en/headlines/society/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics

Circular economy for personal transport

- Designing lighter vehicles, fewer materials to make them = less energy required to power them → reduce 89 MT of CO_2 equivalent/yr by 2050

- Making them last longer → further cut 208 MT CO2 equiv./yr by 2050
- Sharing vehicles → reduce 66 MT CO2 equiv./yr by 2050
- Remanufacturing and reusing an engine is 85% less carbon intensive than making a new one → saving 38 MT CO2 equiv./yr by 2050

Fold-to-form CFRP battery boxes, HP-RTM wishbones | CompositesWorld

Climate change and a circular economy for transport (ellenmacarthurfoundation.org)

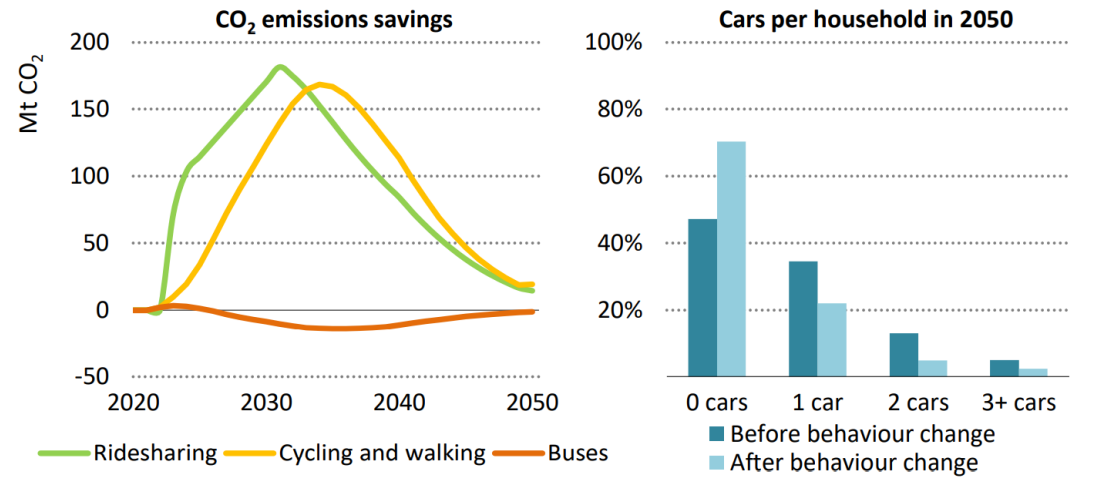
Changing transport requires changing how we move

- Benefits of circular urban design can go beyond reduced emissions from transport
- Can also create safer, more livable cities with resilient communities
  - proximity, density, diversity, and ubiquity.
- The goal? To ensure that all city dwellers are able to reach all the places they need to within a 15-minute walk or bike ride

CityLab | Environment

Paris Mayor: It's Time for a '15-Minute City'

Figure 2.26 ▷ Global CO_2 emissions savings and car ownership per household due to behavioural change in the NZE



Policies discouraging car use in cities lead to rapid reductions in CO_2 emissions and lower car ownership levels, though the impact diminishes over time as cars are electrified

Net Zero by 2050 - A Roadmap for the Global Energy Sector

Aerospace 2050

- Sustainable fuels, operations and propulsion technologies will enable the sector's 2050 net-zero objective
- Airbus foresees demand for 39,000 new passenger & freighter aircraft by 2040

ZEROe concept aircraft

Turbofan

Two hybrid-hydrogen turbofan engines provide thrust. The liquid hydrogen storage and distribution system is located behind the rear pressure bulkhead.

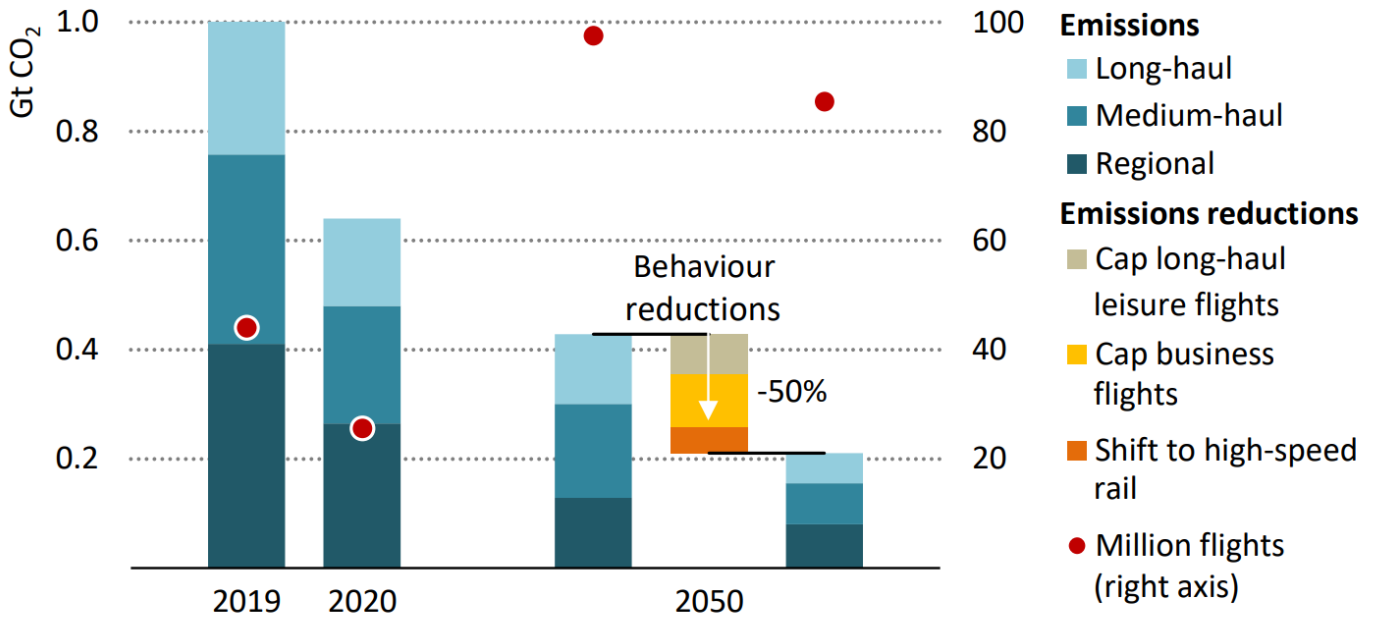
Turboprop

Two hybrid-hydrogen turboprop engines, which drive eight-bladed propellers, provide thrust. The liquid hydrogen storage and distribution system is located behind the rear pressure bulkhead.

Blended-Wing Body (BWB)

The exceptionally wide interior opens up multiple options for hydrogen storage and distribution. Here, the liquid hydrogen storage tanks are stored underneath the wings. Two hybrid-hydrogen turbofan engines provide thrust.

Figure 2.25 ▷ **Global CO_2 emissions from aviation and impact of behavioural changes in the NZE**



Demand for passenger aviation is set to grow significantly by 2050, but behavioural changes reduce emissions by 50% in 2050 despite reducing flights by only 12%

Notes: Long-haul = more than 6 hour flight; medium-haul = 1-6 hour flight; regional = less than 1 hour. Business flights = trips for work purposes; leisure flights = trips for leisure purposes. Average speeds vary by flight distance and range from 680-750 km/h.

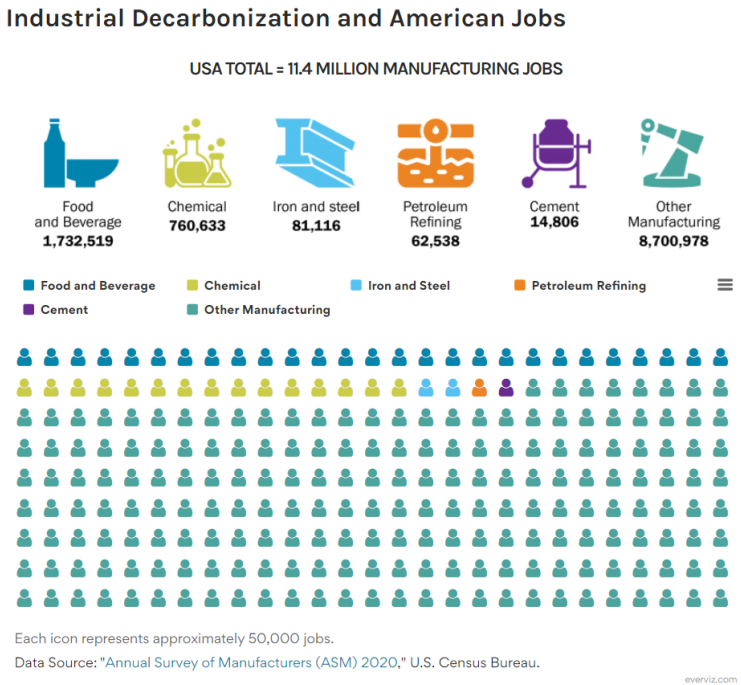
ZEROe - Zero emission - Airbus

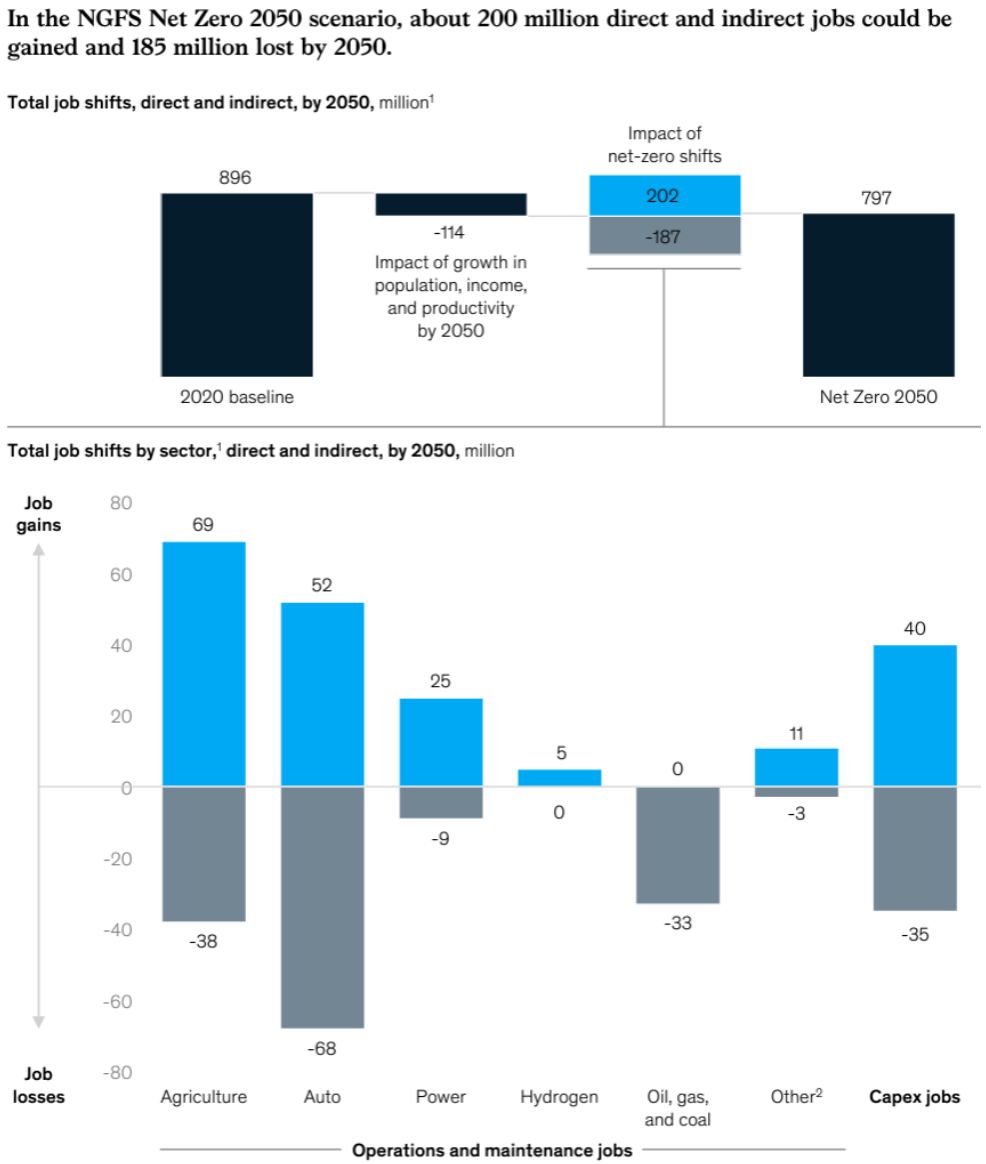
EN-Airbus foresees demand for 39,000 new passenger & freighter aircraft by 2040

Net Zero by 2050 - A Roadmap for the Global Energy Sector

Decarbonization impact on employment

- Jobs: The net-zero transition analyzed here could lead to a reallocation of labor, with about 200 million jobs gained and about 185 million lost by 2050

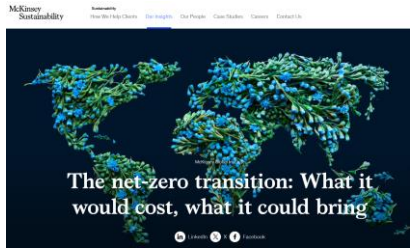




U.S. DEPARTMENT OF ENERGY

Industrial Decarbonization Roadmap

Industrial Decarbonization Roadmap.pdf



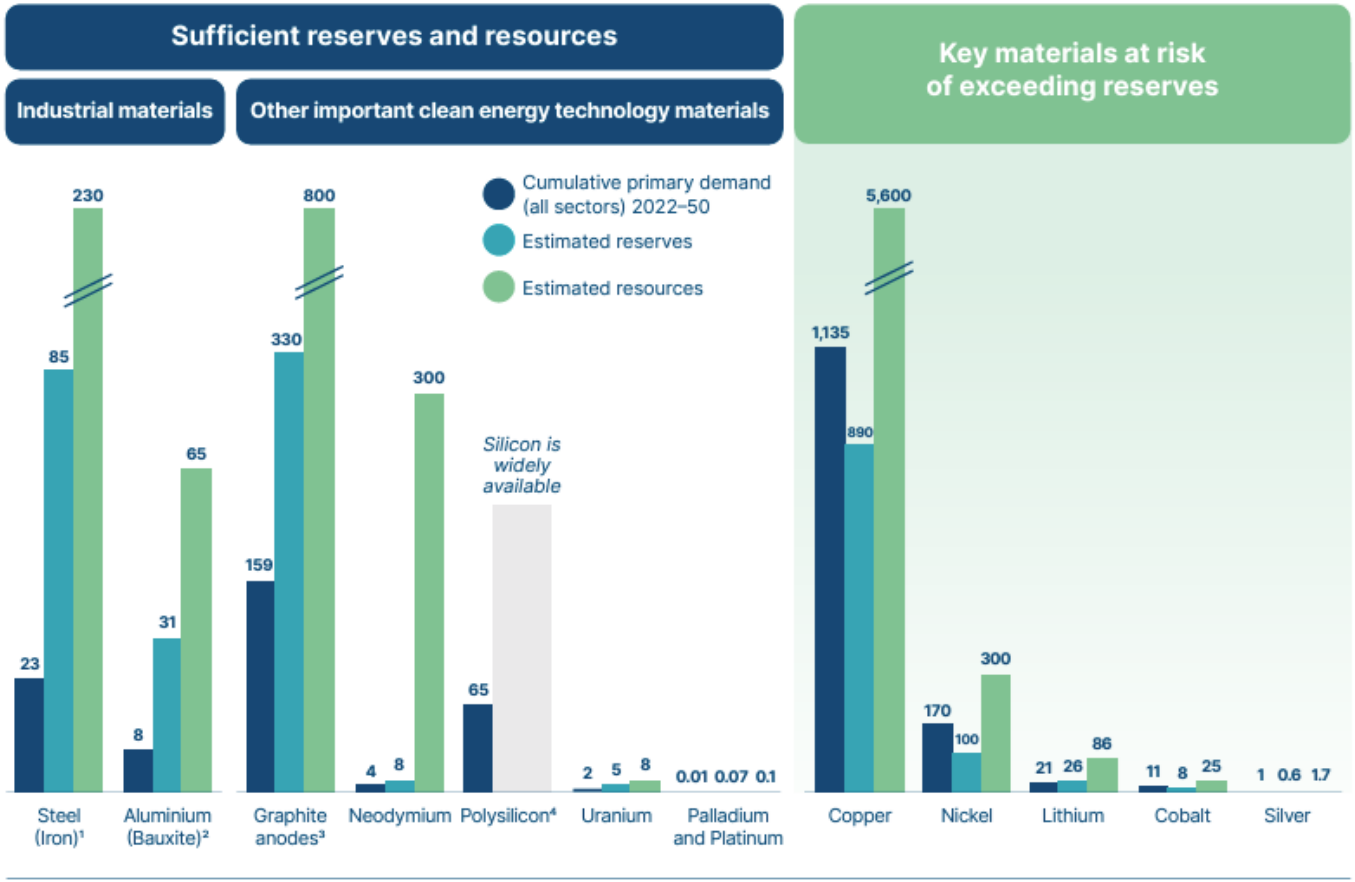
the-net-zero-transition-what-it-would-cost-and-what-it-could-bring-final.pdf

Do we have enough resources?

There are enough resources on land to meet total materials demand between 2022–50, but more exploration to expand reserves will be needed for key energy transition materials

Cumulative primary demand 2022–50 from energy transition and other sectors (Baseline Decarbonisation scenario[5]), compared to estimated reserves and resources

Billion metric tonnes (Industrial materials); Million metric tonnes (All other materials)

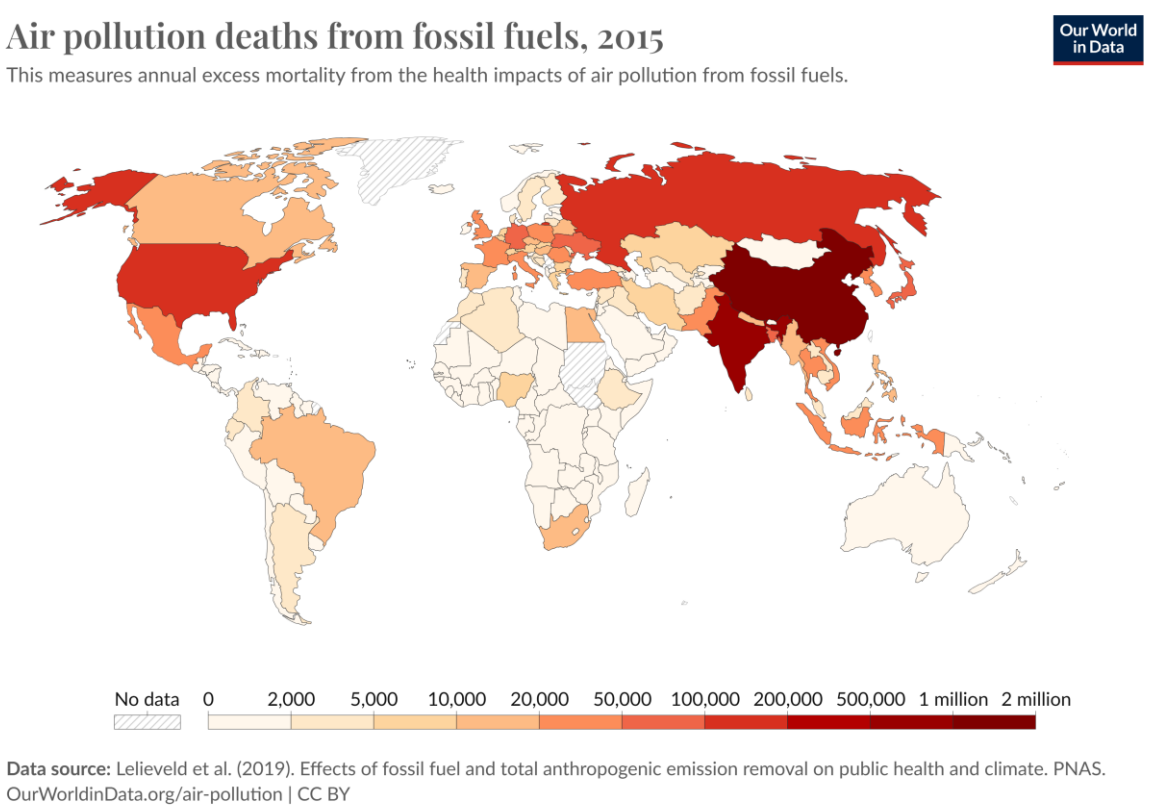


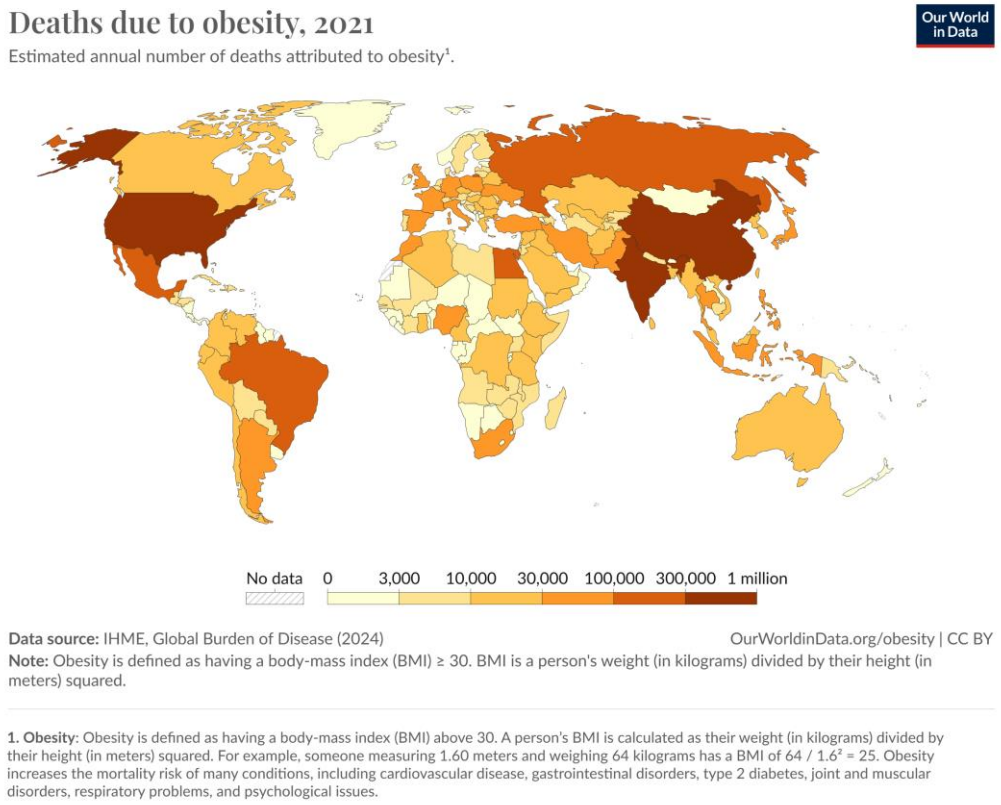
We have enough minerals for the energy transition, but medium-term supply is a challenge [Part 1]

Wakeman

Our current Petro-chemical economy, diet, and human health

- ~ 15 million / yr of our own cause
  - 7 million from air pollution, of which 3.6 million fossil fuel
  - 2.8 million from obesity
  - 5 million from excessive temperatures
- Around same as Covid-19: 14.9 million excess deaths in 2020 and 2021

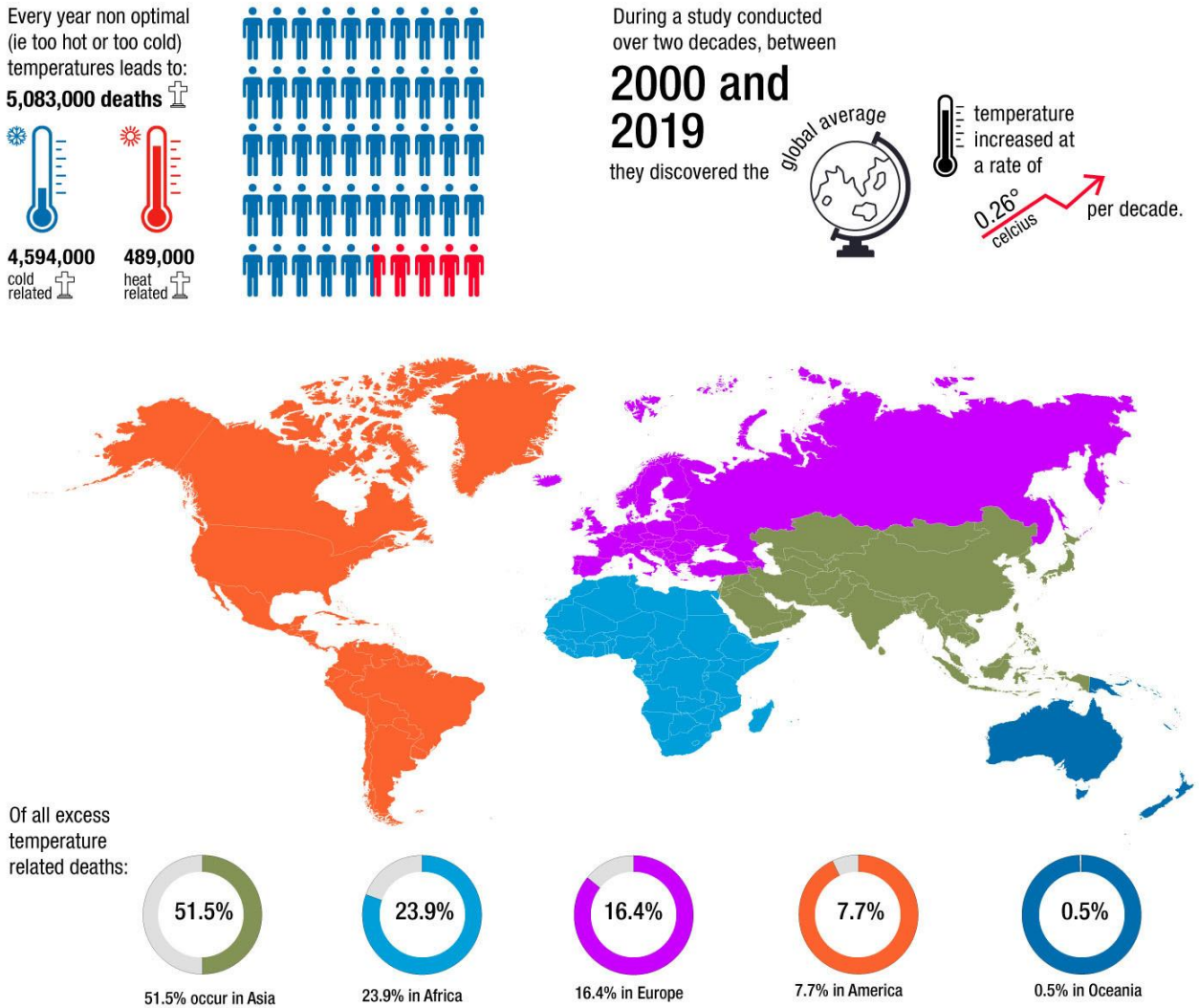




Obesity (who.int) COVID-19 pandemic (who.int) Data review: how many people die from air pollution? - Our World in Data

Climate change and us

- Addressing climate change is not just for the planet …
- It is for us, our family, our neighbors, and our friends and people all over the world we have not yet met

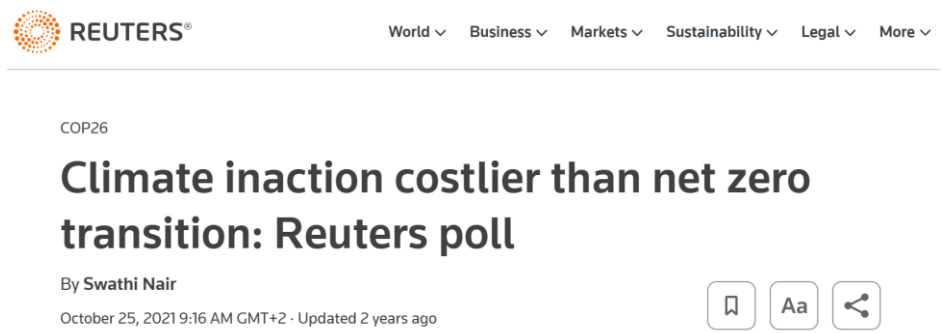


World's largest study of global climate related mortality links 5 million deaths a year to abnormal temperatures - Medicine, Nursing and Health Sciences (monash.edu)

Clear business case for human health: pay back period

- The payback period for achieving net-zero emissions in terms of human health benefits ALONE is around 1 decade (10yrs)

1. **Immediate Benefits**: reductions in air pollution, which can lead to fewer respiratory and cardiovascular diseases. Transitioning to cleaner energy sources can reduce health-related costs and improve quality of life within **1-5 years**[1].
2. **Long-Term Gains**: reduced incidence of chronic diseases linked to climate change (e.g., heat-related illnesses, vector-borne diseases), may take **10-20 years** to fully materialize as the effects of climate change are mitigated[2].
3. **Economic Considerations**: The economic payback from health improvements can also be significant, for every dollar invested in climate action, there can be multiple dollars saved in health costs over time[3].



Yale Experts Explain Net Zero Healthcare | Yale Sustainability
Embedding net zero in health and care for the good of our health and our health service | The BMJ
Realising the health co-benefits of the transition to net zero – UKRI

What is good for us is good for the planet

Dietary changes from current diets toward healthy diets are likely to result in significant health benefits.

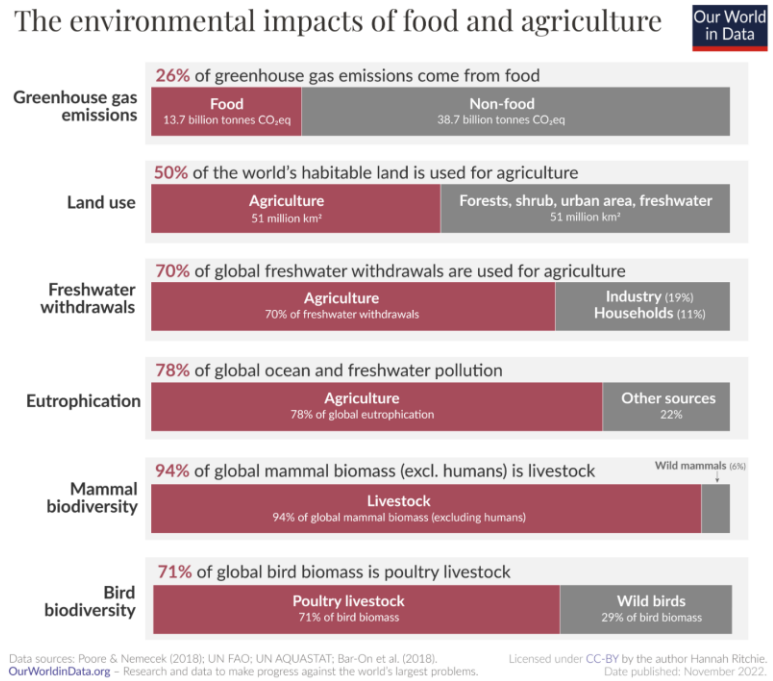
The Commission analyzed the potential impacts of dietary change on diet-related disease mortality using three approaches (see Table 2). All three approaches concluded that **dietary changes from current diets toward healthy diets are likely to result in major health benefits.** This includes preventing approximately 11 million deaths per year, which represent between 19% to 24% of total deaths among adults.

Approach 1 Comparative Risk	19%	or	11.1 million adult deaths per year
Approach 2 Global Burden of Disease	22.4%	or	10.8 million adult deaths per year
Approach 3 Empirical Disease Risk	23.6%	or	11.6 million adult deaths per year

Table 2
Estimated deaths prevented among adults by a global adoption of the planetary health diet.

EAT-Lancet_Commission_Summary_Report.pdf

Figure 3
A planetary health plate should consist by volume of approximately half a plate of vegetables and fruits; the other half, displayed by contribution to calories, should consist of primarily whole grains, plant protein sources, unsaturated plant oils, and (optionally) modest amounts of animal sources of protein. For further details, please refer to section 1 of the Commission.



Environmental Impacts of Food Production - Our World in Data

Summary and Recommendations

- The extraction of raw materials, the use phase of engineered products, and their end-of-life treatment significantly impacts the environment, society, and human health.
- Mining operations, waste disposal methods like incineration and landfilling, and inefficient product lifecycles contribute to pollution, resource depletion, and social inequalities.
- While challenges persist, innovations in technology, sustainable product design, and effective policy frameworks provide hope for reducing the negative impacts.
- Moving toward a circular economy, increasing recycling rates, and adopting cleaner technologies are essential to mitigating these impacts.
- Collaborative efforts between governments, industries, and consumers (STAKEHOLDER ENGAGEMENT) are critical to ensuring a sustainable future for our planet and its inhabitants.