APRIL 28, 2024

# CLEAN ENERGY CLEAN PROFITS:

## HOW TO INVEST IN A BRIGHTER FUTURE

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## Seeking Winners

# CLEAN ENERGY CLEAN PROFITS

## SUMMARY

The headlines scream of rising temperatures, extreme weather events, and melting glaciers. Climate change is no longer a distant threat, but a pressing reality demanding our attention. This in-depth newsletter equips you with the knowledge and resources to navigate the complexities of this global challenge. Get ready to explore:

- **Understanding the Science:** We'll break down the science behind climate change, its far-reaching consequences, and the urgency for action.

- **Identifying the Sources:** From energy production to industrial processes and agriculture, we'll delve into the major culprits responsible for greenhouse gas emissions.

- **Pathways to Decarbonization:** Explore innovative strategies and technologies for reducing emissions from our most significant sources.

- **The Global Response:** We'll examine international climate policies and initiatives designed to foster cooperation and accelerate progress.

- **Investing for a Sustainable Future:** Looking to translate your concern into action? We'll discuss public market investment options that align with a sustainable future.

- **A Clear Roadmap:** We'll conclude with a concise and actionable summary, offering you a clear path forward.

# PART 1 - AN OVERVIEW OF CLIMATE CHANGE

## The Earth's Atmosphere

The Earth's atmosphere is a vital, life-sustaining layer of gases that envelops our planet. It acts as a protective shield, filtering out harmful radiation from the sun and regulating Earth's temperature. But what exactly is this atmosphere made of, and how is it structured?

- **The Dominant Players:** Two gases reign supreme in Earth's atmosphere: Nitrogen (comprising roughly 78%) and Oxygen (at 21%). Nitrogen, though inert for the most part, plays a critical role. It dilutes the oxygen we breathe, preventing spontaneous combustion, and provides essential raw materials for plant growth. Oxygen, of course, is the gas that fuels cellular respiration in most living organisms. Plants replenish atmospheric oxygen through photosynthesis, creating a natural balance. Argon (at 0.9%) makes up the third-largest chunk, another inert gas that helps maintain atmospheric pressure.

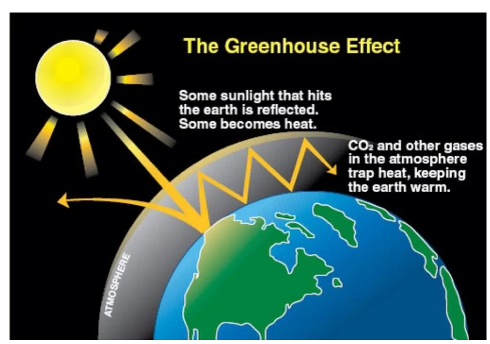
- **The Trace Contributors:** While nitrogen, oxygen, and argon form the bulk of the atmosphere, various trace gases play significant roles:

  - **Water Vapour:** This ever-changing component is most abundant near Earth's surface, influencing weather patterns and forming clouds. Its concentration varies greatly depending on location and temperature.

  - **Carbon Dioxide:** This greenhouse gas acts like a blanket, trapping heat from the sun and contributing to Earth's warmth. However, human activities are causing a concerning rise in its concentration, leading to climate change concerns.

  - **Other Trace Gases:** Tiny amounts of methane, neon, helium, and ozone are also present. Ozone, in particular, plays a vital role by absorbing harmful ultraviolet radiation from the sun.

Earth acts like a giant sponge, soaking up around 70% of the sun's energy that reaches its surface. The remaining 30% bounces back into space, reflecting off clouds, ice, and other bright areas.




Source: TutorBin

## Layers of the Atmosphere

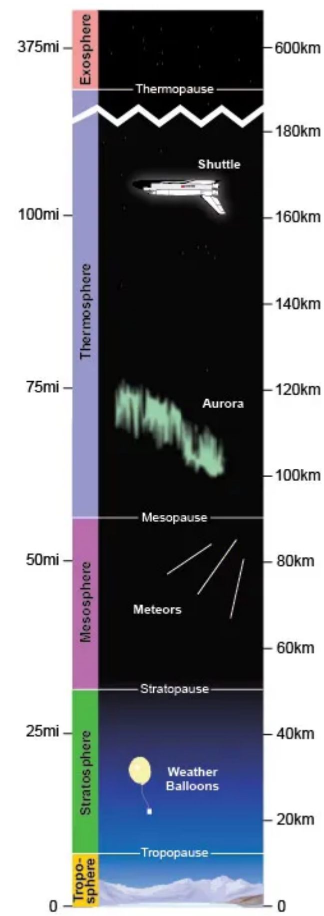
The Earth's atmosphere isn't just a homogenous blend of gases. It's structured into distinct layers, each with unique temperature and pressure characteristics:

- **Troposphere:** Closest to Earth's surface, this is the layer where weather happens. Clouds, rain, wind, and other weather phenomena all take place here.
- **Stratosphere:** As we move upwards, we reach the stratosphere, where temperatures start to rise. This layer is home to the ozone layer, a vital shield that protects us from harmful solar radiation.
- **Mesosphere:** Temperatures plummet in this layer, creating a frigid zone.
- **Thermosphere:** Here, things heat up significantly. The upper reaches of the thermosphere absorb solar radiation, causing temperatures to soar.
- **Exosphere:** The outermost layer, the exosphere is where the atmosphere thins out, eventually merging with the vacuum of space. Particles here have enough energy to escape Earth's gravity.

## Air Pressure

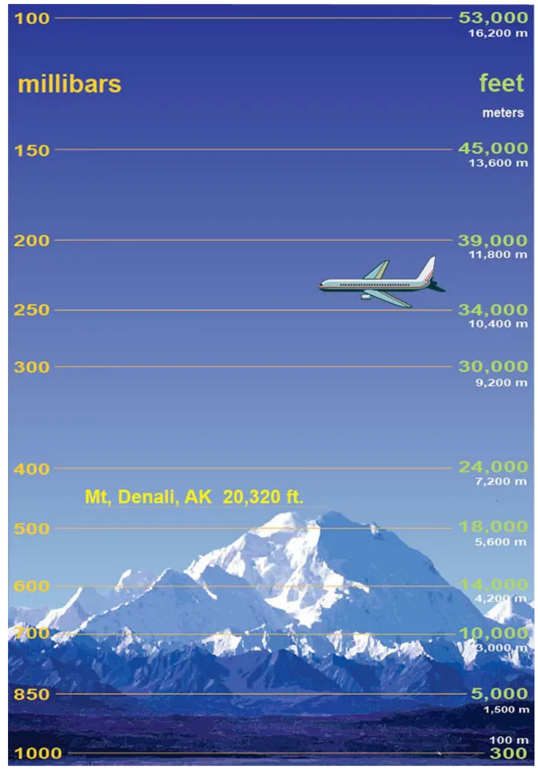
As you travel upwards through the Earth's atmosphere, air pressure steadily decreases. This happens because air pressure is caused by the weight of air molecules pressing down on you.

- **Thinner Air, Less Pressure:** Air pressure is directly proportional to the density of air molecules. As you move higher, the atmosphere thins out – there are fewer air molecules per unit volume. This translates to a decrease in air pressure. It's like having fewer weights stacked on top of you, resulting in less pressure.
- **The Rate of Decrease:** The rate at which air pressure decreases with altitude isn't constant. It's generally around 3.5 millibars per every 30 meters (100 feet) of ascent. However, this rate can be influenced by temperature. Colder air is denser, so the pressure decrease might be slightly less pronounced in colder regions.




Source: NOAA

Here's a breakdown of the pressure changes across different layers:

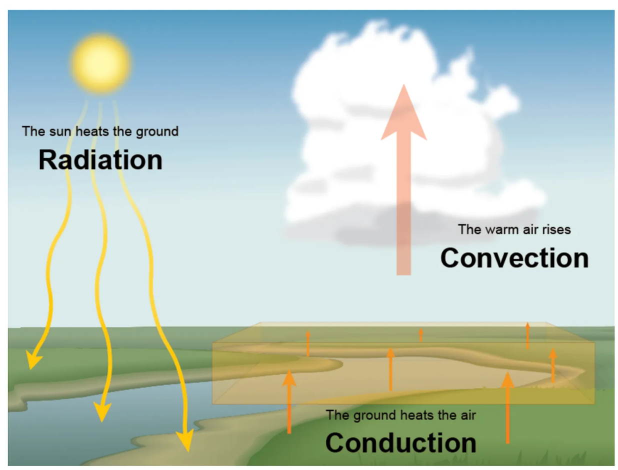



Source: NOAA

- **Troposphere:** This is the layer where most of the pressure decrease happens. Since most weather phenomena occur here, pressure variations can be noticeable during weather events.
- **Stratosphere:** The pressure continues to decrease in the stratosphere, but at a slower rate compared to the troposphere.
- **Mesosphere and Thermosphere:** As the atmosphere thins out even further in these upper layers, the pressure drops significantly. These layers are very low in pressure compared to the troposphere.

## The Transfer of Heat Energy

The Sun's energy reaches Earth and warms our atmosphere through three main mechanisms:




Source: NOAA

1. **Radiation:** This is the dominant mode of energy transfer. The Sun emits electromagnetic radiation across a spectrum, with visible light being just a small portion. A significant amount of this radiation reaches Earth as shortwave radiation (high energy, short wavelength). Most of this shortwave radiation passes directly through the atmosphere and heats the Earth's surface. Some shortwave radiation is reflected back into space by clouds, ice, and other reflective surfaces. The Earth's surface, warmed by the absorbed radiation, then emits long wave radiation (lower energy, longer wavelength) back towards the atmosphere. However, some atmospheric gases like water vapour and carbon dioxide trap this long wave radiation, contributing to the greenhouse effect and warming the atmosphere.

2. **Conduction:** This method involves the transfer of heat through direct contact between particles. In the context of the atmosphere, conduction plays a minor role. Since air is a poor conductor, it's only near the Earth's surface, where the ground and air molecules are in direct contact, that conduction contributes to heat transfer. The sun's heat warms the land and water surfaces, which then transfer some of that heat to the lowest layers of air by conduction.

3. **Convection:** This is the most important mechanism for transferring heat within the atmosphere. Uneven heating of the Earth's surface by the Sun causes warm air parcels to rise. As they rise, they expand and cool due to the decreasing pressure at higher altitudes. This cooler air eventually sinks back down towards the surface. This circular motion of air, driven by temperature differences, is called convection currents. These currents transport heat from the warm surface (especially landmasses) to cooler regions of the atmosphere, influencing weather patterns like wind and cloud formation.

### The Earth-Atmosphere Energy Balance

Earth's climate is maintained by a delicate balance between incoming and outgoing energy. This balance is crucial for regulating Earth's temperature and ensuring a habitable planet.

**Incoming Solar Energy:**

- The Sun bathes Earth in shortwave radiation, a form of electromagnetic energy with a shorter wavelength and higher energy content.
- This radiation travels through space and interacts with Earth's atmosphere.

**Energy Pathways in the Atmosphere:**

- A portion of the incoming solar radiation is reflected back to space by clouds, ice caps, and other bright surfaces on Earth.
- The remaining radiation is absorbed by the Earth's surface and the atmosphere.
- The warmed Earth emits thermal infrared radiation (long-wave radiation) back towards space.

**The Importance of Balance:**

- For a stable climate, the total amount of energy absorbed by Earth needs to be balanced by the total amount of energy radiated back out to space.

- If this balance is disrupted, Earth's temperature will change.

**Factors Affecting the Balance:**

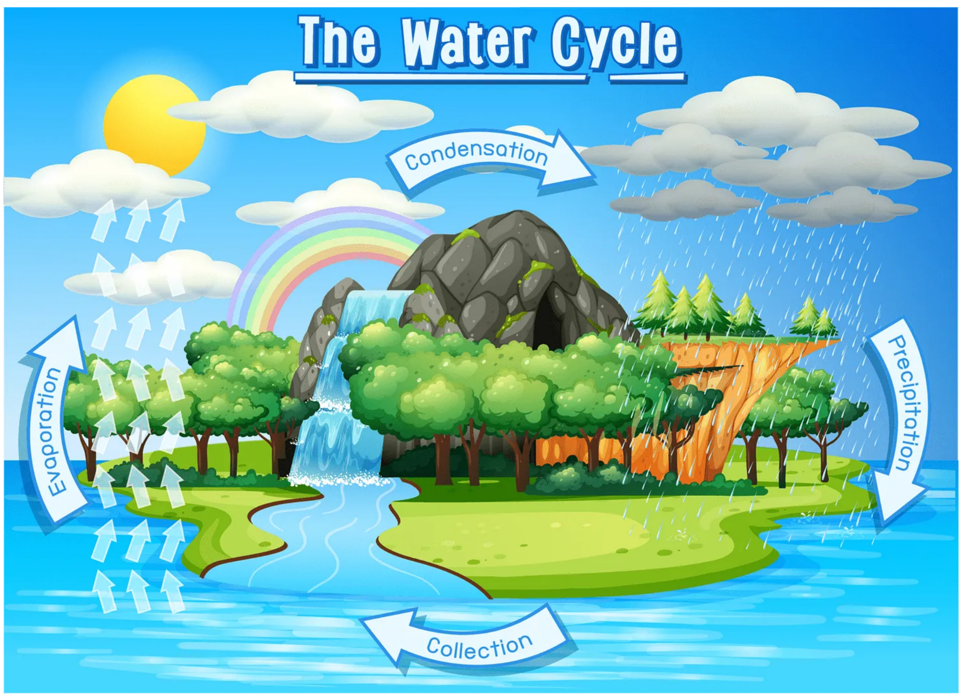
- Changes in the amount of incoming solar radiation can affect the balance.
- This can be caused by natural factors like solar activity cycles, but also by human activities that release greenhouse gases.
- Greenhouse gases like carbon dioxide trap outgoing infrared radiation, preventing it from escaping to space. This additional trapped heat contributes to global warming.

**Hydrologic Cycle**

The hydrologic cycle, also known as the water cycle, is the continuous movement of water on, above, and below Earth's surface. It's a vital system that shapes our planet's climate, ecosystems, and weather patterns. This cycle has no beginning or end; it's a never-ending loop where water constantly changes its state (liquid, vapour, ice) as it travels through various stages.

- **The Sun:** The primary driving force behind the hydrologic cycle. Solar radiation provides the energy needed to evaporate water from various surfaces.
- **Evaporation:** Liquid water transforms into water vapour and enters the atmosphere. This process occurs from oceans, lakes, rivers, moist soil, and even plant leaves. Wind also plays a role, carrying the water vapour away from its source.
- **Transpiration:** Plants release water vapour through tiny pores on their leaves, a process crucial for their survival. This adds significant amounts of moisture to the atmosphere, contributing to overall evaporation.
- **Condensation:** As water vapour rises in the cooler atmosphere, it condenses around microscopic particles like dust or salt, forming clouds. The temperature at which condensation occurs is called the dew point.
- **Precipitation:** When enough water droplets or ice crystals condense in clouds, they become too heavy to stay suspended and fall back to Earth's surface in various forms – rain, snow, hail, sleet, or freezing rain.
- **Runoff:** Water that falls on land and doesn't infiltrate the ground becomes runoff. It flows over the surface, eventually reaching streams, rivers, lakes, and ultimately the oceans.

- **Infiltration:** A portion of the precipitation soaks into the ground, replenishing groundwater stores that lie beneath the surface. The amount of infiltration depends on factors like soil type, vegetation cover, and the rate of rainfall.
- **Percolation:** Water that infiltrates the ground may percolate deeper, moving through soil and rock layers until it reaches an aquifer, an underground layer of saturated rock or sediment.
- **Storage:** Water is temporarily stored in various reservoirs during the hydrologic cycle – oceans, lakes, glaciers, snowpack, and groundwater all play a role.




Source: LearningMole

## Greenhouse Gases

The four main types of greenhouse gases that contribute to global warming are:

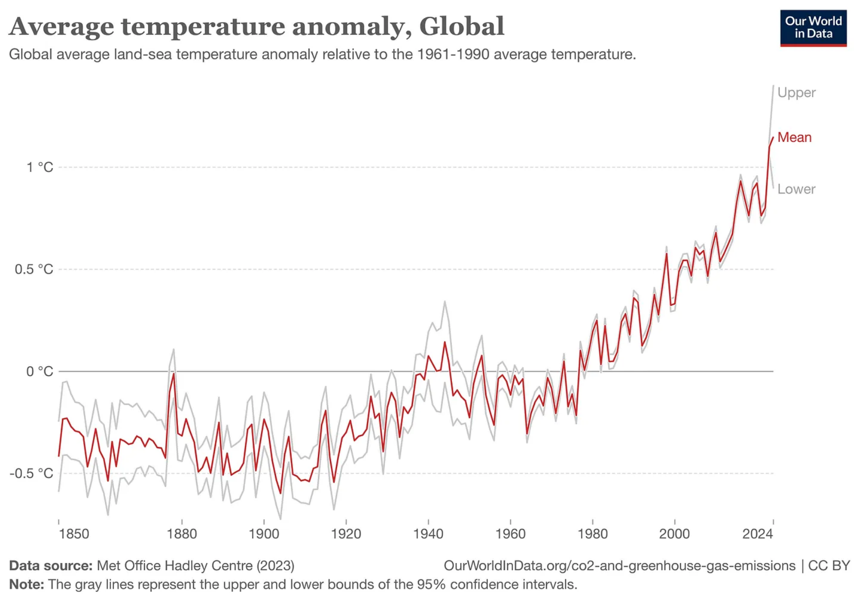
- **Carbon Dioxide ($CO_2$):** This is the most abundant greenhouse gas emitted by human activities. It's released through burning fossil fuels like coal, oil, and natural gas, deforestation, and industrial processes. $CO_2$ traps heat efficiently, and its atmospheric concentration has been steadily rising due to human activities.
- **Methane ($CH_4$):** While less abundant than $CO_2$, methane is a potent greenhouse gas, trapping significantly more heat per molecule. It's emitted from agriculture (animal manure, rice cultivation), waste decomposition in landfills, and the fossil fuel industry (natural gas leaks).
- **Nitrous Oxide ($N_2O$):** This gas is produced in agricultural practices using fertilizers, industrial processes like nylon production, and the burning of fossil fuels. Like methane, nitrous oxide is a powerful heat-trapping gas, although its atmospheric concentration is much lower.
- **Fluorinated Gases:** This category encompasses various man-made gases used in refrigerants, air conditioners, fire extinguishers, and industrial applications. Some common examples include hydrofluorocarbons (HFCs), per fluorocarbons (PFCs), sulphur hexafluoride ($SF_6$), and nitrogen trifluoride ($NF_3$). These gases are extremely potent greenhouse gases and can linger in the atmosphere for thousands of years.

| | Carbon Dioxide ($CO_2$) | Methane ($CH_4$) | Nitrous Oxide ($N_2O$) | Fluorinated Gases |
|---|---|---|---|---|
| Concentration in atmosphere | ~420 parts per million | ~1,900 parts per billion | ~330 parts per billion | ~100 parts per trillion |
| Lifetime in atmosphere | ~300-1,000 years | ~12 years | ~110 years | A few weeks to thousands of years |
| Removal from atmosphere | Removed by ocean, forest and other carbon sinks | Removed by oxidation into carbon dioxide and water | Removed by sink or destroyed through chemical reactions | Gradually broken down by UV in upper atmosphere |

Source: NOAA, IEA & NASA

## Rising Global Temperatures

**Climate Change Isn't Coming, It's Here:** We can no longer view climate change as a distant threat. The Earth's climate is already undergoing significant transformations due to human-caused greenhouse gas emissions. The evidence is undeniable: glaciers are melting, ice is breaking up earlier, plant and animal life are migrating to new territories, and spring is arriving sooner.



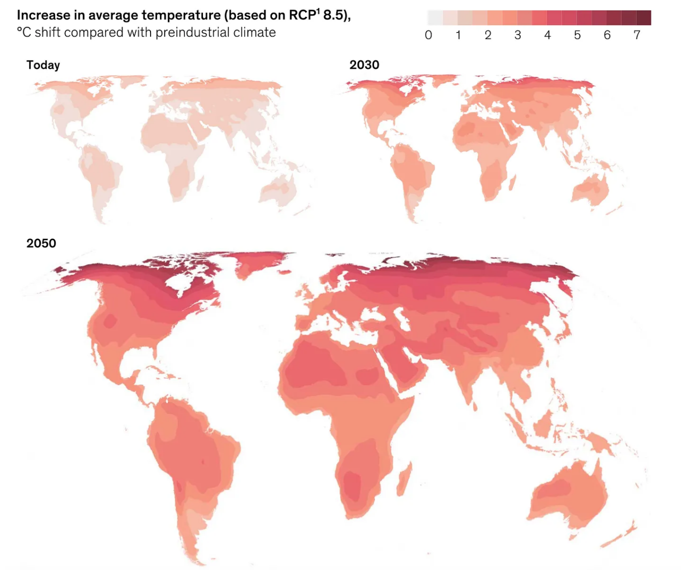

Source: Our World in Data

The reality of climate change is hitting us faster than scientists predicted. We're experiencing weather extremes like droughts, wildfires, and intense rainfall with greater frequency and intensity. The Intergovernmental Panel on Climate Change (IPCC), a UN body dedicated to climate science, confirms this. They state that the current global climate changes are unprecedented in human history, and some will be irreversible for centuries or millennia to come.

**The Cause is Clear: Human Activity:** Scientists are highly confident that rising global temperatures are a direct result of greenhouse gases released by human activities.

**The IPCC's Stark Warning:** Their latest report (2021) reveals that human-caused emissions have already warmed the planet by nearly 1.1 degrees Celsius (2°F) compared to pre-industrial levels. They predict an average global temperature increase exceeding 1.5°C (3°F) within the next few decades. These changes will impact every corner of the Earth.

According to McKinsey, global temperatures have increased as the concentration of greenhouse gases in Earth's atmosphere have risen. In there report, "Climate Risk and Response: Physical Hazards and Socioeconomic Impacts" they state the rise in temperatures will cause:




Source: McKinsey

- **Increased Frequency and Intensity of Physical Hazards:** Climate change is expected to lead to more frequent and severe extreme weather events like floods, droughts, heatwaves, and rising sea levels.

- **Socioeconomic Impacts Across Various Sectors:** These physical hazards will have cascading effects, impacting various socio-economic sectors like:

  - **Livability and workability:** Extreme weather events can disrupt infrastructure, displace populations, and make certain areas less habitable.
  - **Food systems:** Changes in temperature and precipitation patterns can affect agricultural yields and food security.
  - **Physical assets:** Infrastructure like buildings, roads, and power grids can be damaged by extreme weather events.
  - **Infrastructure services:** Disruptions to power supply, transportation networks, and other essential services can occur due to climate hazards.
  - **Natural capital:** Ecosystems and biodiversity can be negatively affected by changes in climate.
  - **Unequal Distribution of Risks:** The impacts of climate change will not be evenly distributed. Developing countries and vulnerable communities are often less equipped to handle these challenges.

### How to Prevent Further Warming?

There are two ways we could reduce further warming.

1. **Reflect** more sunlight back into space using geothermal engineering

Reflecting sunlight back into space using geothermal engineering is a theoretical concept for mitigating climate change.

**Geothermal Energy Source:** This method would utilize heat from the Earth's core to power machines that create reflective particles or aerosols in the atmosphere.

- Challenges and Considerations:
    - The technology is still in the theoretical stage and hasn't been tested at scale.
    - The potential environmental impacts of injecting aerosols into the atmosphere are not fully understood. It could disrupt weather patterns or harm the ozone layer.
    - The ethical implications of such a large-scale manipulation of the planet's climate need careful consideration.

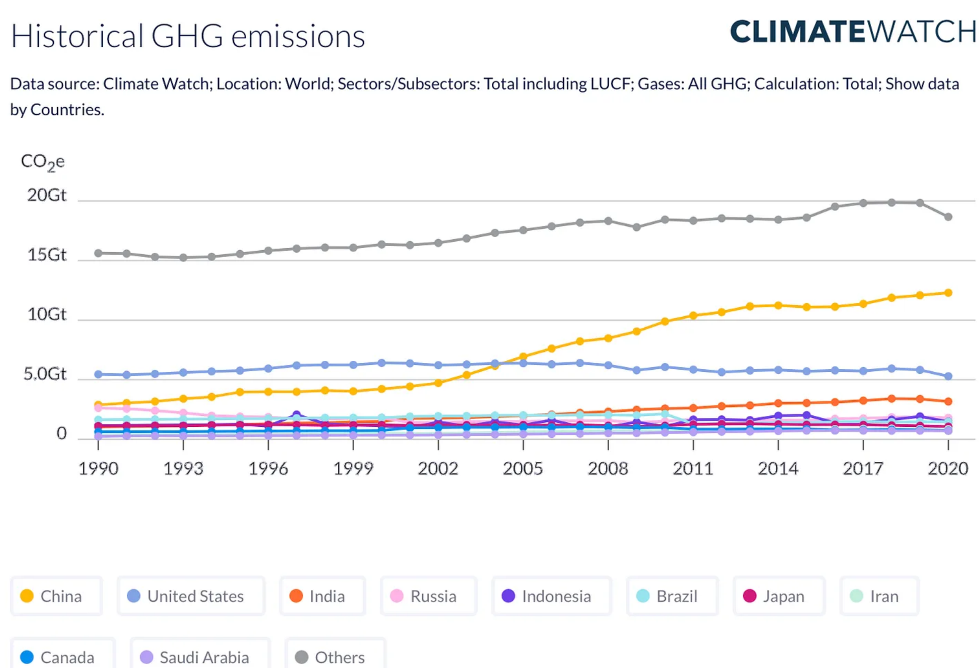
2. **Reducing** greenhouse gas emissions through renewable energy, energy efficiency, and sustainable practices.

# PART 2 - SOURCES OF EMISSIONS

According to the Emissions Gap report 2023, Pollution from heat-trapping gases (GHG) reached an all-time peak in 2022, jumping 1.2% from the previous year. This translates to a staggering 57.4 gigatons of carbon dioxide equivalent (GtCO2e).

- Aside from transportation, all other sectors have bounced back completely from the pandemic's emissions dip and now surpass 2019 levels.
- The biggest culprits? Burning fossil fuels and industrial processes, responsible for about two-thirds of the overall increase.
- But it's not just CO2. Methane, nitrous oxide, and fluorinated gases, all with a more significant warming impact, are also on the rise. These gases make up about a quarter of current emissions, and their growth is concerning:
    - F-gas emissions saw the fastest increase at 5.5%, followed by methane (1.8%) and nitrous oxide (0.9%).

The top countries responsible for the increase in emissions over time are who you would expect, but the question is really where are these emissions coming from?




Source: Climate Watch

## Breakdown of Global Greenhouse Gas Emissions by Sector

### Energy Sector (73.2%)

- Burning fossil fuels for electricity, heat, and transport is the largest contributor (over two-thirds) within this sector.
- Industry uses a significant portion of energy, with iron and steel, chemicals, and food processing being the biggest industrial polluters.
- Transportation accounts for 24% of emissions, with road transport being the most significant contributor.

### Buildings (17.5%)

- Residential and commercial buildings contribute to emissions through energy use for heating, appliances, and lighting.

### Other Sectors

- Unallocated fuel combustion (7.8%) includes emissions from biomass, nuclear, and other energy sources.
- Fugitive emissions from energy production (5.8%) arise from leaks during oil, gas, and coal extraction and transportation.
- Agriculture and fishing (1.7%) contribute through machinery use.

### Industrial Processes (10.4%)

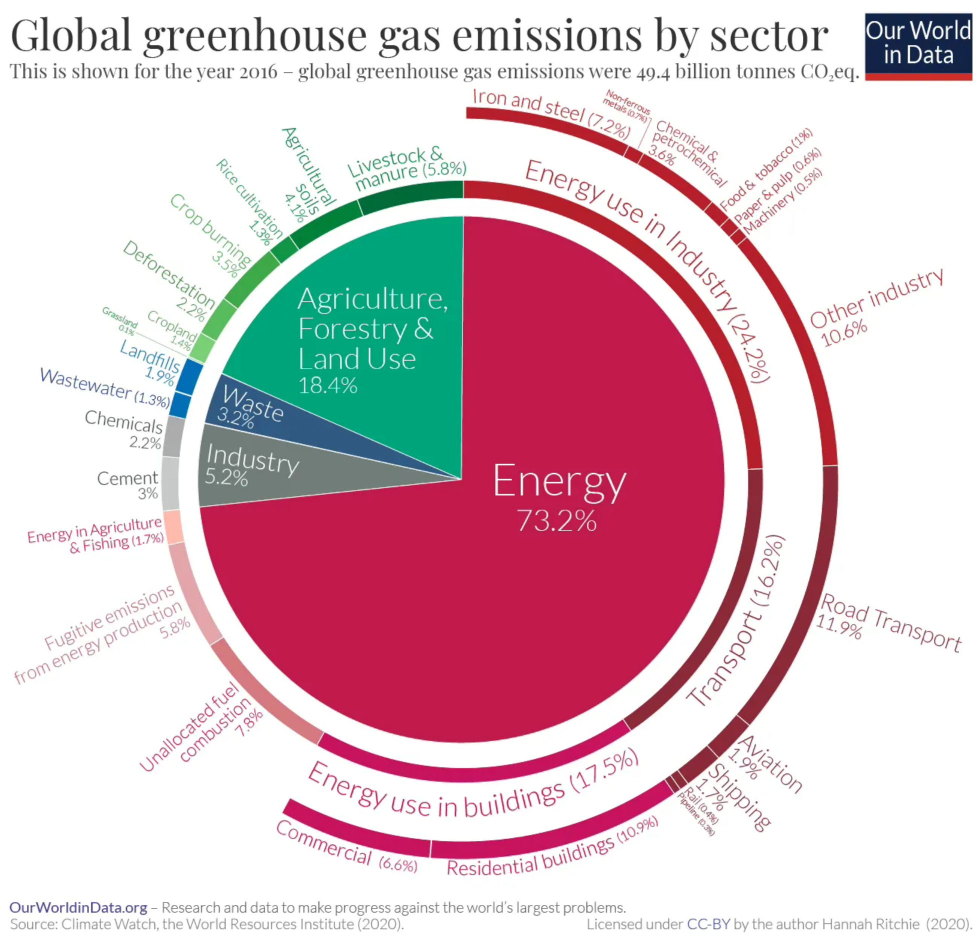
- Cement production releases CO2 as a byproduct.
- Chemical and petrochemical manufacturing also generates emissions during production processes.

### Waste (3.2%)

- Wastewater treatment produces methane and nitrous oxide from decomposing organic matter.
- Landfills generate methane as organic waste decomposes.

### Agriculture, Forestry, and Land Use (18.4%)

- This sector includes emissions from various agricultural practices, deforestation, and land-use changes.
- Livestock is a major contributor due to methane emissions from their digestive systems.
- Rice cultivation generates methane in flooded paddy fields.
- Deforestation releases stored carbon dioxide when forests are cut down.

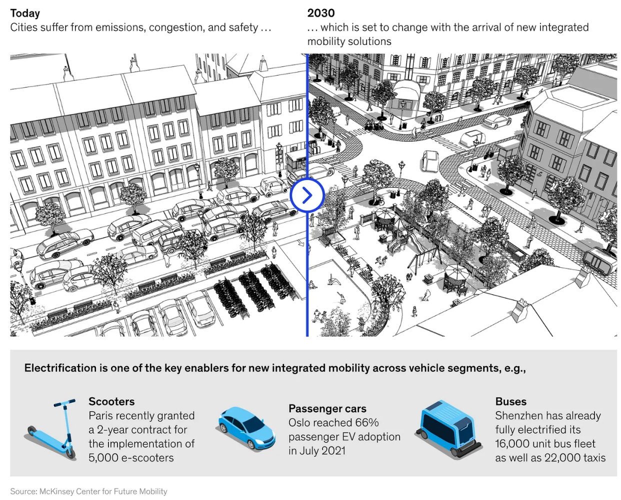


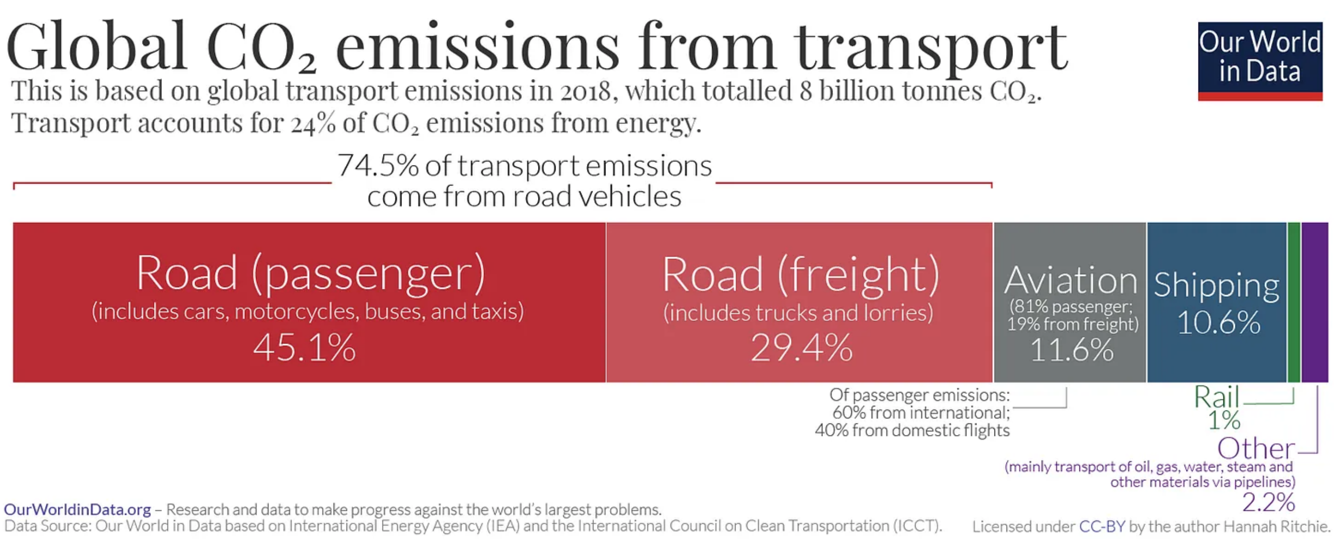

Source: Our World in Data

# PART 3 - DECARBONIZING CORE EMISSION SOURCES

## Decarbonizing Transportation

Transportation is a significant contributor to global climate change, responsible for roughly one-fifth (24% if considering only CO2 emissions from energy) of global CO2 emissions. But how exactly does this breakdown among different modes of transport?




The graphic (source: International Energy Agency) reveals that road travel dominates, accounting for a whopping three-quarters of transport emissions.

- **Passenger cars and buses** are the biggest culprits, contributing **45.1%** of total transport emissions.
- **Trucks** hauling freight follow closely behind, responsible for **29.4%.**

This translates to **road transport alone generating 15% of all CO2 emissions.**

While **aviation** often sparks heated discussions on climate action, it contributes a significantly smaller share – just **11.6%** of transport emissions. This translates to roughly **2.5% of total global emissions** (around 1 billion tonnes of CO2 annually).

**International shipping** falls in a similar range, emitting **10.6%** of transport emissions.

**Railways** (both passenger and freight) and other transport (mainly pipelines) contribute minimally, emitting only **1% and 2.2%** of transport emissions respectively.

Given that transportation makes up 24% of global emissions and road transportation makes up a staggering 45% of the transportation emissions, finding a way to decarbonize vehicles would make sense.

The push is to move towards battery and Plug-In Hybrid Electric Vehicle Engines because they emit fewer emissions than internal combustion engines.

The electric vehicle (EV) revolution is gaining momentum, driven by sustainability concerns and evolving regulations. However, a critical challenge stands in the way of widespread EV adoption: battery supply. McKinsey & Company's report, "Unlocking growth in battery cell manufacturing for electric vehicles," sheds light on this bottleneck and proposes solutions to ramp up production.

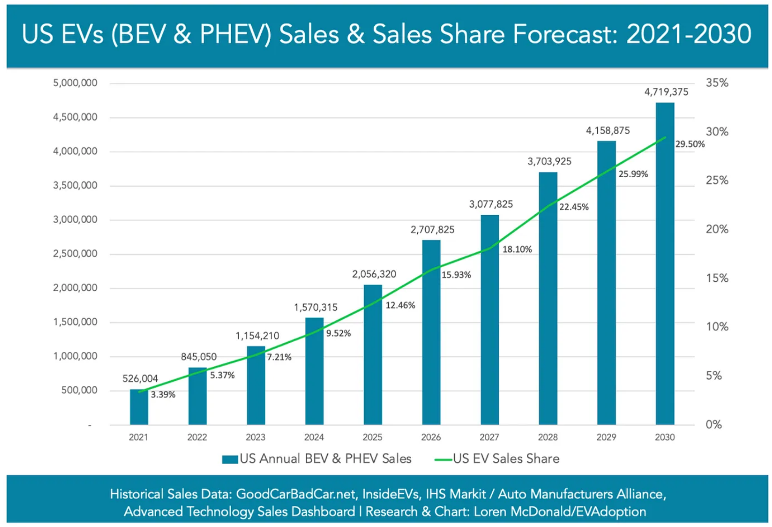
The report highlights the surging demand for EV batteries, projected to reach a staggering 4.7 terawatt hours (TWh) by 2030. This exponential growth threatens to outpace current battery cell manufacturing capacity. While established players and new ventures are building gigafactories (large-scale battery plants), significant efforts are needed to bridge the supply gap.

McKinsey emphasizes the need for collaboration across the industry. Building the necessary manufacturing capabilities requires a multi-pronged approach:

- **Scaling Up Production:** Existing facilities need to optimize production processes and embrace automation for faster output.
- **Geographical Expansion:** New battery plants need to be strategically located in key EV markets to ensure regional supply chains and reduce reliance on any single source.
- **Technological Advancements:** Investing in research and development of next-generation battery technologies with higher energy density and faster charging times is crucial.

## The Future of Electric Vehicles: Will We See a Significant Shift by 2030?

Electric vehicles (EVs) are becoming increasingly popular, but will they be able to take over the roads by 2030? Looking at sales forecasts for EVs and how many gas-powered vehicles (ICEs) will still be on the road in the next few years it appears that EV's can in fact substitute internal combustion engines (ICE) over time.




Even though EV sales are expected to rise significantly by 2030, there will still be 20 million more ICE vehicles on the road than there are today. This is due to the fact that older vehicles tend to stay on the road for a long time. Additionally, many automakers are not currently prioritizing EVs (aside from Tesla & BYD).

EVs are rapidly transforming the transportation landscape, but their silent hum masks a complex network – the EV battery supply chain. Understanding this intricate journey, from raw materials buried deep within the earth to the battery powering your car, is crucial for ensuring a sustainable and secure EV future.

## The Battery's Epic Journey: From Mine to Machine

The story of an EV battery begins deep within the earth's crust. **Upstream**, mines extract vital minerals like lithium, cobalt, nickel, and manganese. These raw materials embark on a journey of transformation, traveling to **midstream** facilities where processors refine them into usable components like cathodes and anodes, the heart of any battery cell.

**Downstream**, battery manufacturers take these refined materials and assemble them into individual battery cells. These cells are then packaged and delivered to automakers, where they are meticulously integrated into the electric vehicle architecture. Interestingly, some forward-thinking car companies are recognizing the strategic importance of


Source: RMI

batteries and are partnering with battery manufacturers or even establishing their own production capabilities.

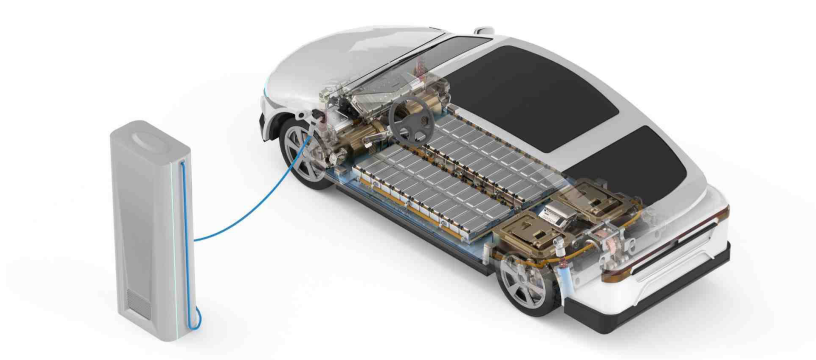
The story doesn't end there. When EV batteries eventually reach the end of their lifespan in a vehicle, they enter the **end-of-life stage**. Here, responsible practices come into play. Ideally, these batteries are reused in less demanding applications or meticulously recycled to recapture valuable materials and minimize environmental impact.

### Economic Opportunities and the Jobs Landscape

The transition to EVs undoubtedly disrupts the traditional automotive workforce. While EV production requires fewer people due to simpler designs, this transformation creates a wealth of new opportunities. The downstream and midstream segments of the EV battery supply chain, encompassing battery manufacturing, component production, and material processing, are expected to be significant job creators. These new opportunities may not be concentrated in the same geographical areas as traditional auto manufacturing jobs, necessitating workforce retraining and relocation programs.

However, the economic benefits of the EV revolution extend far beyond job creation. It fosters innovation! New companies like Tesla and Rivian are challenging established automakers, leading to a more competitive and dynamic marketplace that spurs cutting-edge battery technology and efficient vehicle designs. This spirit of innovation is further fuelled by the upstream segment of the supply chain, where companies are constantly exploring new and sustainable methods for extracting and processing battery materials.

The economic potential of the EV battery supply chain doesn't stop there. Localizing battery production across the globe unlocks investment opportunities. Billions of dollars are pouring into critical mineral processing facilities, battery component manufacturing plants, and recycling infrastructure. This not only strengthens national economies but also reduces reliance on any single country for battery production, fostering a more secure and resilient supply chain.



## The Global EV Battery Landscape: A Call for Diversification

Currently, China dominates the EV battery supply chain, controlling a significant portion of the mining, processing, and manufacturing processes. This concentration creates a vulnerability – disruptions in China can ripple throughout the entire global EV market. To mitigate this risk, diversification is key. Governments around the world are recognizing this and are implementing policies to encourage domestic battery production and strengthen partnerships with other resource-rich countries.

## Embracing Battery Circularity: A Closed-Loop Approach

The concept of battery circularity is paramount for a sustainable EV future. By prioritizing battery recycling and reuse, we can minimize waste, reduce the environmental footprint of battery production, and lessen dependence on virgin materials. Technological advancements in battery recycling are crucial for achieving this goal.

## Addressing Ethical Concerns: A Moral Imperative

Unfortunately, the mining of battery materials has sometimes been linked to human rights abuses and environmental damage. There's a growing movement to increase transparency throughout the supply chain, ensuring ethical sourcing practices and holding companies accountable for their environmental and social impact.

## Decarbonizing Aviation

Electric aircraft are poised to revolutionize regional travel, driven by several key factors:

- **Cost Savings:** Electric planes promise significant operational cost advantages for airlines. Lower fuel and maintenance costs could breathe new life into unprofitable routes, making regional travel more accessible.
- **Focus on Regional Routes:** Shorter flights are ideal for electric aircraft due to current battery limitations. This presents an opportunity to revitalize under utilized regional airports, bringing air travel closer to more people.
- **Environmental Benefits:** Electric planes are quieter and produce fewer emissions, especially compared to short-haul gas-powered aircraft. This can improve air quality and reduce noise pollution near airports.
- **Reduced Reliance on Subsidies:** Electric aircraft have the potential to make regional air service profitable, reducing the need for government subsidies to maintain connectivity to smaller communities.
- **Economic Growth:** Electric aviation could unlock new economic opportunities by serving previously underserved areas, reviving general aviation airports, and fostering innovation in the aerospace industry.

Electric airplanes are a glimpse into a cleaner, quieter future for regional travel. However, a major hurdle stands in their way – how to efficiently and rapidly charge these innovative aircraft.

**The Battery Bottleneck:** Electric planes, like Eviation's Alice, require massive batteries (over 800 kWh) to achieve a decent range. These batteries are significantly larger than their counterparts in electric cars. While this translates to longer flight times, it also means much longer charging times.

**The Need for Speed:** Current charging technology simply can't handle these behemoth batteries. Recharging them in under 30 minutes, a critical benchmark for commercial viability, remains out of reach.

**Building the Infrastructure:** Even if faster charging solutions emerge, building the infrastructure to support them presents a significant challenge. Traditional megawatt-level charging stations used for electric cars won't suffice.

## Charging on the Horizon: Potential Solutions

Despite the challenges, a wave of innovation is tackling the electric airplane charging conundrum. Here are some promising approaches:

- **Parallel Charging:** This strategy involves using multiple charging units simultaneously to juice up an airplane battery. While it essentially fast-tracks the process, it adds complexity and requires additional equipment.
- **Wireless Charging:** Imagine the convenience of simply taxiing an airplane onto a charging pad. Wireless charging eliminates the need for bulky cables and connectors. However, there are concerns about the powerful electromagnetic fields generated during wireless charging, which could potentially interfere with sensitive aircraft avionics and lightning protection systems. Safety will be paramount in ensuring this technology doesn't disrupt critical airplane systems.
- **Nanoelectrofuel Flow Batteries:** This futuristic concept replaces the traditional battery charging process with a fluid exchange. Imagine swapping out battery fluids instead of plugging in! This technology is still under development by companies like Influit Energy with funding from NASA, but it holds promise for overcoming the limitations of conventional batteries.

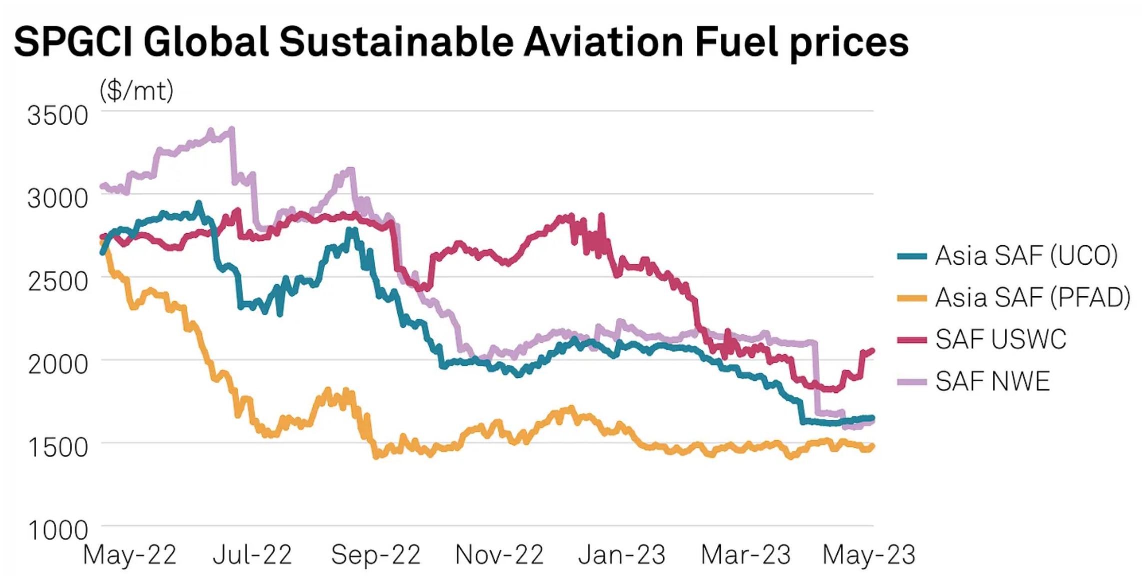
Given electric planes creation and charging appears to be well off into the future of commercial use; it makes sense for us to tackle the jet fuels we're currently using first.

Sustainable aviation fuel (SAF) is a game-changer for airlines looking to reduce their environmental impact. Made from renewable sources like plant oils, greases, and even waste materials, SAF offers similar performance to traditional jet fuel, but with a significantly smaller carbon footprint. This means airlines can take action to reduce greenhouse gas emissions without sacrificing flight performance.

- **A Feast of Sustainable Feedstocks:** The good news is that there's no shortage of potential ingredients for SAF. From corn and algae to used cooking oil and municipal waste, a vast array of renewable and waste resources can be used to create SAF. This abundance ensures a reliable supply chain and reduces dependence on fossil fuels.

- **Beyond Reduced Emissions:** The Benefits of SAF: The advantages of SAF extend far beyond just cleaner skies. Growing crops for SAF production creates new economic opportunities for farmers, while also improving soil quality and reducing erosion. Additionally, using waste materials like manure for SAF production helps keep harmful methane gas out of the atmosphere. Even aircraft performance can benefit from SAF, with some varieties burning cleaner and reducing harmful emissions around airports.
- **Jobs Take Flight with Domestic SAF Production:** The United States is a leader in biofuel production, and expanding domestic SAF production can create even more jobs across the country. From farmers growing feedstock crops to engineers building biorefineries and aviation professionals maintaining the infrastructure, SAF is a boon for the American economy.

Thankfully we're seeing global SAF prices drop drastically and combined with government regulation forcing some countries to integrate SAF into their planes, this should be the quickest route to reducing aviation emissions over time.



Source: S&P Global Commodity Insights

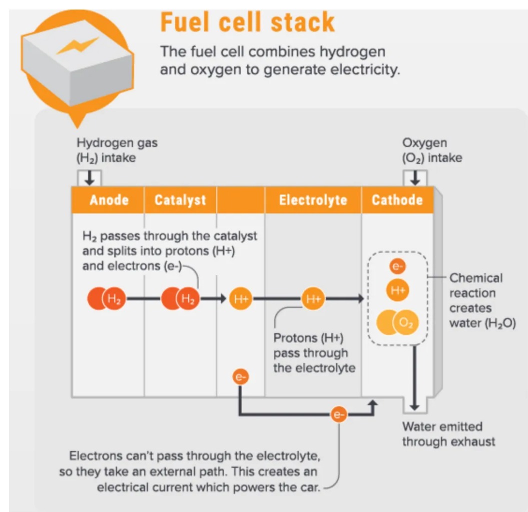
## Decarbonizing Shipping

A future where ships glide across the ocean without spewing harmful pollutants. This vision is becoming a reality thanks to hydrogen fuel cells. These innovative devices convert hydrogen and oxygen into electricity, emitting only water vapour – a clean alternative to traditional diesel and heavy fuel oil. Unlike batteries, they don't require recharging, but rather a steady supply of hydrogen fuel.

### Why Hydrogen? Benefits for a Cleaner Ocean

For centuries, maritime transportation relied on fossil fuels, taking a toll on our environment. Hydrogen fuel cells offer a game-changing solution:

- **Cleaner Seas:** By generating zero greenhouse gas emissions, hydrogen cells significantly reduce a ship's carbon footprint. This helps combat climate change and protects marine ecosystems.
- **Quieter Voyages:** Hydrogen cells operate much quieter than combustion engines, creating a more peaceful environment for crew and marine life.
- **Extended Range:** Hydrogen fuel cells offer greater range compared to batteries, allowing ships to travel farther without refuelling.
- **Faster Refuelling:** Refuelling hydrogen is a quicker process than recharging batteries, minimizing downtime and maximizing operational efficiency.




Source: Visual Capitalist

- **Retrofit Ready:** Existing ships can be retrofitted with hydrogen fuel cells, accelerating the transition to a cleaner maritime industry.
- **Storage Solutions:** Unlike wind and solar, hydrogen fuel can be stored for long periods, making it ideal for long ocean voyages.

The hydrogen revolution in maritime transport has already begun. Pioneering projects like the MF Hydra ferry in Norway demonstrate the viability of this technology. This hydrogen-powered ferry boasts a 95% reduction in carbon emissions, paving the way for a greener future.

## Building the Infrastructure for a Hydrogen Future

For hydrogen to reach its full potential, a robust infrastructure is needed:

- **Hydrogen Production Facilities:** Ports need readily available hydrogen supplies to fuel these clean vessels.
- **Refuelling Stations:** A network of hydrogen refuelling stations needs to be established along trade routes.
- **Safety Regulations:** Clear safety standards for handling and storing hydrogen are crucial.
- **Collaborative Efforts:** Collaboration between governments, industries, and research institutions is essential to drive investments, policy changes, and knowledge sharing.

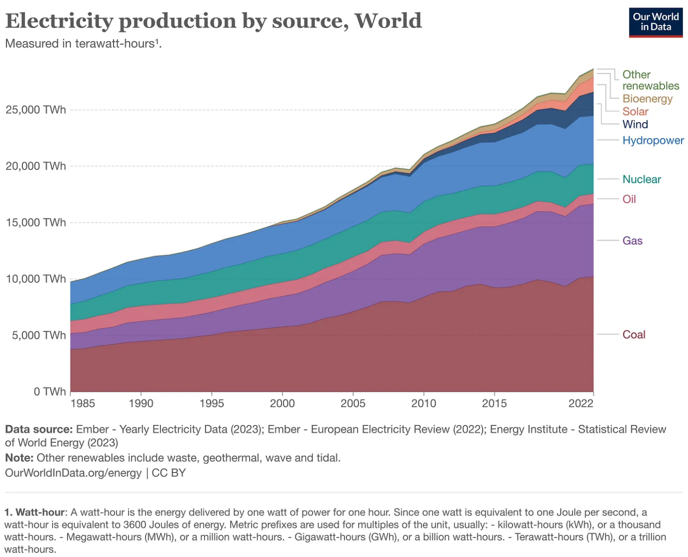
## H2Ports: A Real-World Example

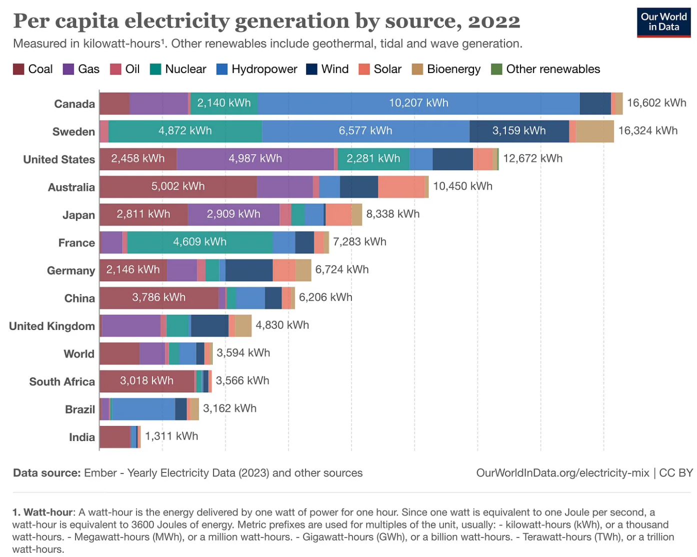
The H2Ports initiative at the Port of Valencia showcases the power of collaboration. This project tests hydrogen-powered port equipment and aims to become the first European port offering green hydrogen fuel to cargo ships. This groundbreaking initiative, including the world's first hydrogen-powered terminal tractor, sets a global example for sustainable port operations.

## Decarbonizing Power

Fossil fuels dominate global electricity production, with coal leading the pack followed by natural gas. Among cleaner alternatives, hydropower and nuclear are the major players, but wind and solar are rapidly gaining ground.

On a country-by-country basis, the electricity mix can change significantly over time.




### How does Burning Coal & Natural Gas Produce Energy?

Burning coal and natural gas follow the same basic principle: they release chemical energy stored in the fuel through combustion (burning) to create heat, which is then used to generate electricity. Here's a step-by-step breakdown:

- **Burning the Fuel:**
  - **Coal:** Coal is crushed into a fine powder and fed into a large furnace where it's burned.
  - **Natural Gas:** Natural gas is piped into the furnace and ignited.
- **Heat Transfer:**
  - The burning fuel heats up water inside a network of tubes surrounding the furnace.

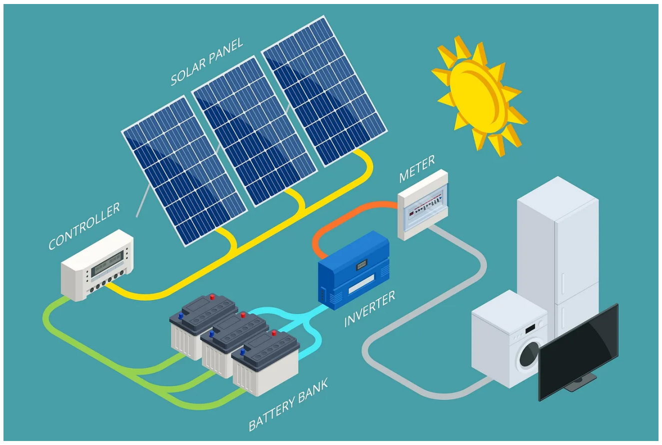
- **Steam Generation:**
    - The hot water absorbs so much heat that it turns into high-pressure steam.
- **Spinning the Turbine:**
    - The high-pressure steam is directed towards the blades of a turbine, causing them to spin rapidly. This turbine is essentially a giant fan.
- **Electricity Generation:**
    - The spinning turbine shaft is connected to a generator. As the turbine shaft spins, the generator uses the principles of electromagnetism to convert the mechanical energy of the spinning shaft into electrical energy. This is the electricity that gets transported to homes and businesses.

## Renewable Energy Sources

There are multiple sources of renewables that can replace the above process over time.

**Solar panels** use the photovoltaic effect to convert sunlight directly into electricity. Here's a breakdown of the process:

- **Sunlight Captures Electrons:** Sunlight is made up of tiny packets of energy called photons. When these photons strike a solar panel, they hit the silicon atoms within the panel's photovoltaic cells.
- **Electrons on the Move:** The energy from the photons disrupts the orderly structure of the silicon atoms, causing them to loosen electrons. These free electrons are able to move around within the cell.

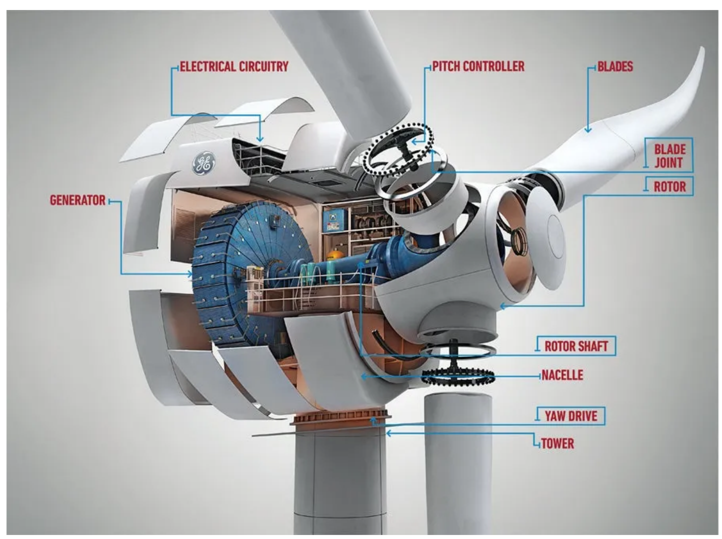



- **The Semiconductor Effect:** A solar cell is made of two layers of silicon, one with a positive electrical charge (p-type) and the other with a negative charge (n-type). This creates an electric field within the cell.

- **Directed Flow:** The freed electrons naturally want to flow from the negative layer to the positive layer due to the electric field. This movement of electrons creates an electric current.
- **Harvesting the Electricity:** Thin metal fingers embedded within the solar cell collect the flowing electrons and channel them to external wires. This current can then be used to power devices or be fed into the power grid.
- **Direct Current vs. Usable Electricity:** The electricity generated by solar panels is initially direct current (DC). Most appliances in our homes and businesses use alternating current (AC). Inverters are used to convert the DC electricity from the solar panels into AC electricity that can be used by our devices.

**Wind turbines** operate on a fairly simple principle, essentially using wind as an invisible "driver" to spin a shaft connected to a generator, which then produces electricity.

- **Wind Captures the Blades:** Wind flows across the large blades of the turbine, similar to how it might push a pinwheel.
- **Lift and Drag:** The shape of the blades is crucial. They are designed to create lift, much like an airplane wing. As wind passes over the curved surface of the blade, it creates a lifting force that pushes the blade upwards. Additionally, the wind also exerts a dragging force against the blade as it moves. The lift force is much stronger than the drag force, causing the blade to rotate.

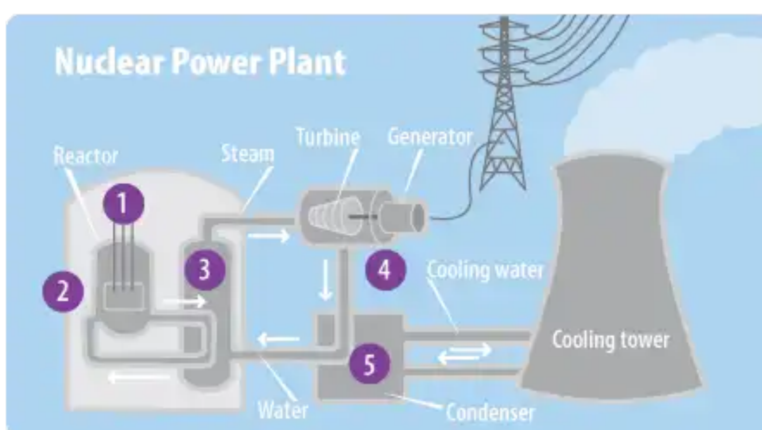



- **Rotational Chain Reaction:** The rotation of one blade transfers energy to the other blades through a shaft connecting them. This creates a combined force that spins the main shaft of the turbine.
- **Spinning the Generator:** The main shaft of the turbine is connected to a gearbox. The gearbox increases the rotational speed of the shaft (similar to how gears on a bike change speed). This faster-spinning shaft is then connected to a generator.

- **Electricity Generation:** The generator is essentially a machine that converts mechanical energy (the spinning shaft) into electrical energy. Through the principles of electromagnetism, the rotation of the shaft inside the generator creates electricity.
- **Controlling the Speed:** Wind turbines have control systems that can adjust the angle of the blades to optimize their performance based on wind speed. In very high winds, the blades may be angled slightly to slow down the rotation and prevent damage.

**Nuclear power** plants generate electricity through a process called nuclear fission, which involves splitting atoms of certain heavy elements to release a tremendous amount of energy.

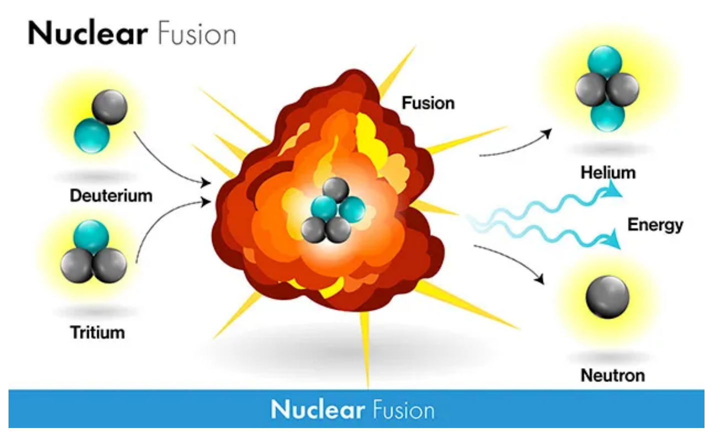
- **Fuel Source:** Nuclear power plants use enriched uranium, a fissile isotope (easily splittable atom) of uranium. Small pellets containing enriched uranium are stacked together to form fuel rods, which are then bundled into assemblies and loaded into the reactor core.
- **Initiating the Chain Reaction:** A controlled nuclear chain reaction is the heart of the process. A neutron (a subatomic particle) is introduced into a uranium-235 atom in the fuel rod. This neutron collides with the nucleus of the uranium-235 atom, splitting it.
- **Energy Release:** When the uranium-235 nucleus splits, it releases a significant amount of energy in the form of heat and additional neutrons. These newly released neutrons can then go on to split other uranium-235 atoms, causing a chain reaction.
- **Controlling the Reaction:** Control rods made of materials that absorb neutrons are inserted into the reactor core. By adjusting the position of these control rods, operators can regulate the rate of the chain reaction, ensuring it proceeds at a safe and controlled pace.
- **Heat Transfer:** The fission process generates immense heat within the reactor core. This heat is transferred to a coolant, typically water, circulating around the core. The hot coolant doesn't boil but becomes highly pressurized water.



- **Steam Generation:** The hot pressurized water from the reactor core is pumped to a heat exchanger, where it transfers its heat to another water system. This secondary water system boils, generating steam.
- **Spinning the Turbine:** The high-pressure steam from the heat exchanger is directed towards the blades of a turbine, causing them to spin rapidly. This turbine is essentially a giant fan.
- **Electricity Generation:** The spinning turbine shaft is connected to a generator. As the turbine shaft spins, the generator uses the principles of electromagnetism to convert the mechanical energy of the spinning shaft into electrical energy. This is the electricity that gets transported to homes and businesses.

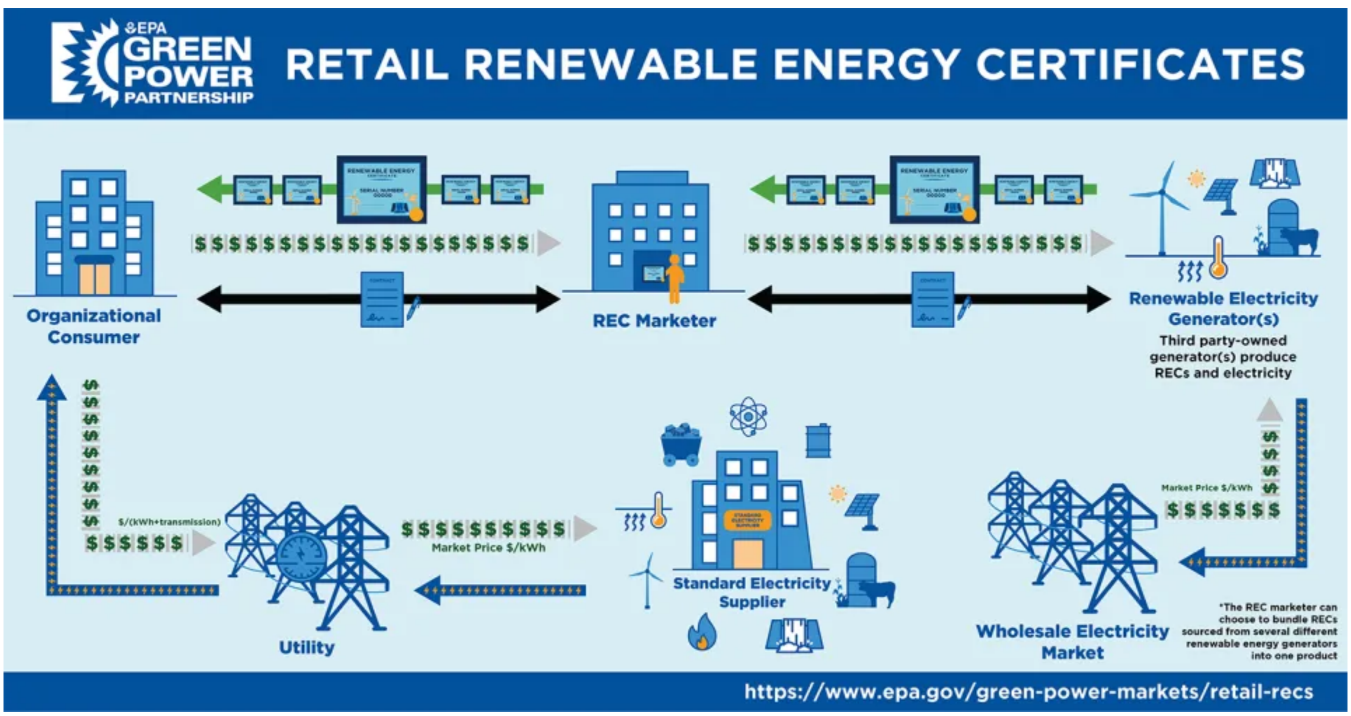
**Nuclear fusion** is the process that powers stars like our sun. Unlike nuclear fission used in power plants today, fusion involves combining atomic nuclei instead of splitting them. This releases a tremendous amount of energy, with some key advantages:

- **Fuel Source:** Nuclear fusion uses readily available isotopes of hydrogen, deuterium and tritium, found in seawater. This makes it a virtually limitless fuel source compared to the finite supplies of uranium used in fission.
- **Merging Nuclei:** The goal of fusion is to fuse the nuclei of these hydrogen isotopes to form a heavier element, usually helium. However, forcing these positively charged nuclei to overcome their natural repulsion requires immense heat and pressure.
- **Extreme Conditions:** To achieve fusion, scientists create a state of matter called plasma. Here, electrons are stripped away from hydrogen atoms, leaving behind positively charged ions and free-moving electrons. This superheated plasma is then confined using powerful magnetic fields. Temperatures inside a fusion reactor can reach millions of degrees Celsius, hotter than the sun's core.
- **Overcoming Repulsion:** Under these extreme conditions, the nuclei begin to move at incredibly high speeds. If they get close enough, the strong nuclear force overpowers the electrical repulsion between the positively charged nuclei, allowing them to fuse.



- **Energy Release:** When fusion occurs, a significant amount of energy is released in the form of heat and neutrons. This heat can then be used to generate electricity in a similar way to a nuclear fission reactor (using steam turbines and generators).
- **Challenges and Progress:** Achieving and sustaining a controlled fusion reaction is extremely difficult. Scientists are constantly working on various approaches to confine plasma and maintain the necessary conditions for fusion to occur. While there are no commercial fusion reactors yet, significant progress has been made in research labs around the world.

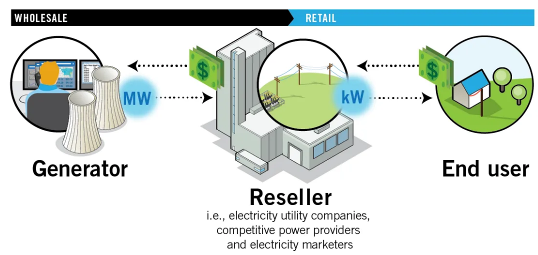
**Power markets, also known as electricity markets**, are essentially marketplaces where electricity is bought and sold. They play a crucial role in ensuring a reliable and efficient supply of electricity to homes and businesses. Here's a breakdown of how they typically function:



## The Players:

- **Generators:** These are the companies that produce electricity using various methods like burning fossil fuels, harnessing wind or solar power, or nuclear fission.
- **Retail Electricity Providers (REPs):** These companies buy electricity in bulk (wholesale) from the market and then sell it to consumers like you, often with different plans and rates.
- **Independent System Operator (ISO) or Regional Transmission Organization (RTO):** This is an independent organization that manages the electricity market. They ensure the grid remains stable and secure by balancing supply and demand for electricity.

## The Process:




- **Wholesale Market:** Generators submit bids indicating how much electricity they can produce and at what price. REPs and other buyers submit bids for how much electricity they need and at what price they are willing to pay.
- **Market Clearing:** The ISO/RTO uses sophisticated software to match buy and sell orders, determining the market price for electricity at a specific point in time (often an hour or shorter). This price is based on supply and demand – higher demand or lower supply will drive the price up, and vice versa.
- **Generators Get Paid:** Generators are paid based on the amount of electricity they produce and the market price at the time of production.
- **REPs Sell to Consumers:** REPs purchase electricity at the wholesale market price and then sell it to consumers according to their chosen plans, which may include fixed or variable rates.

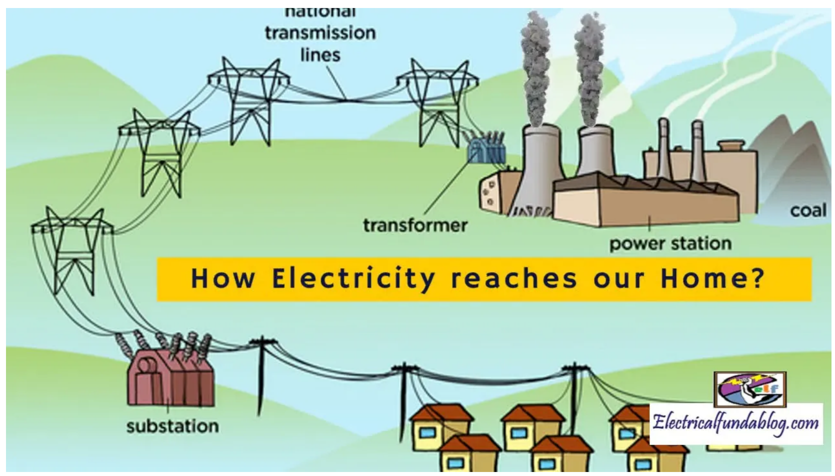
When it comes to electricity, some areas have competitive retail markets. In these markets, various companies, called retail electricity suppliers (RES), can buy electricity in bulk (wholesale) directly from power plants. These RES companies then sell this electricity to individual consumers (end-users) at their homes and businesses. The utility company, in this scenario, acts as a behind-the-scenes facilitator. They maintain the power lines, transformers, and other infrastructure to ensure everyone gets the electricity they need, regardless of who sells it.

## The Journey of Electricity to Your Home

Electricity, the invisible power that fuels our modern lives, takes a fascinating journey before it reaches your outlets.

- **Power Generation:** Electricity is produced at power plants using various methods like burning fossil fuels, harnessing sunlight or wind power, or utilizing nuclear fission. Each method converts a source of energy into electricity.

- **Transmission:** The raw electricity generated at power plants is not suitable for long-distance travel. High-voltage transformers significantly increase the voltage, creating a more efficient transmission process. Imagine this high-voltage electricity traveling along long-distance power lines, similar to a high-speed highway for electricity.




- **Substations:** These crucial stations act as voltage regulators. They receive the high-voltage electricity and step it down to lower voltages suitable for distribution within neighbourhoods. This is like reducing the speed on a highway exit ramp to safely enter local streets.

- **Distribution:** A network of smaller power lines carries the stepped-down electricity throughout your neighbourhood. These lines are typically visible along streets and alleys.

- **Transformation Again:** Before reaching your home, another transformer further reduces the voltage to a level safe for household appliances (typically 120 or 240 volts). This final step ensures the electricity is delivered at a usable and safe voltage.

- **Your Home Connection:** Finally, the electricity reaches your home through a service line and meter. The meter tracks your electricity usage, similar to how you might keep track of how much party favour candy you've enjoyed! The electricity then flows through wires within your walls, powering everything from lights and appliances to entertainment systems.

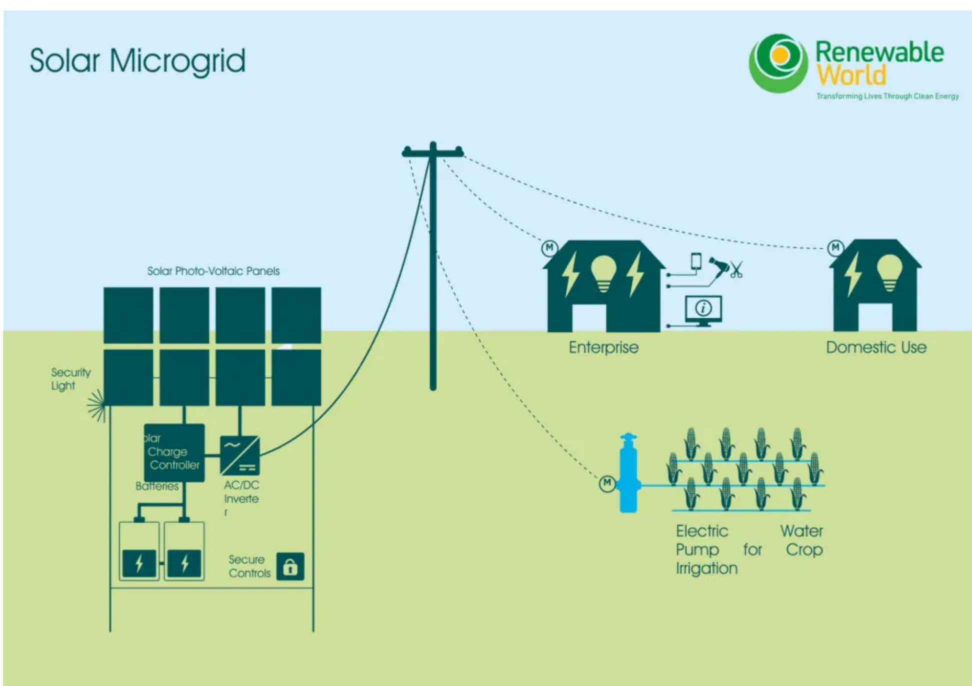
## Risk Areas

Integrating renewable energy sources like solar and wind into the electricity grid offers a path towards a cleaner future, but it's not without its challenges. Here are some key risks to consider:

- **Variability and Intermittency:**
  - Unlike traditional power plants fuelled by coal or natural gas, which can be adjusted to meet demand, solar and wind power generation fluctuate based on weather conditions. This variability can make it difficult to balance supply and demand for electricity on the grid, especially when large amounts of renewable energy are present.
  - **Possible Solutions:** Improved forecasting methods, energy storage technologies (batteries), and utilizing backup power plants from traditional sources can help mitigate these challenges.
- **Grid Infrastructure Needs:**
  - The current electricity grid infrastructure may not be fully equipped to handle the two-way flow of power inherent with some renewables, such as rooftop solar panels feeding power back into the grid. Additionally, transmitting renewable energy from remote locations like wind farms may require grid upgrades.
  - **Possible Solutions:** Investing in grid modernization and expanding transmission capacity are crucial for integrating more renewables.
- **Curtailment:**
  - In some situations, there may be times when renewable energy production exceeds demand. This can lead to curtailment, where renewable energy sources are essentially turned off or limited to avoid overloading the grid. This reduces the overall benefit of these sources.
  - **Possible Solutions:** Improved coordination between grid operators and renewable energy producers, developing better energy storage solutions, and increasing demand for electricity during peak production times can help reduce curtailment.

- **Cybersecurity Threats:**
  - The growing integration of complex technologies in the grid increases the potential for cyberattacks. Hackers targeting control systems could disrupt the flow of electricity, including renewable energy sources.
  - **Possible Solutions:** Implementing robust cybersecurity measures and constantly updating security protocols are essential to protect the grid infrastructure.
- **Social and Environmental Impacts:**
  - While renewable energy offers a cleaner alternative, considerations like land use for solar farms and wind turbines, the environmental impact of manufacturing and disposal of solar panels and wind turbine components, and the potential impact on wildlife need to be carefully evaluated and addressed.
  - **Possible Solutions:** Careful planning, responsible siting of renewable energy projects, and research into improving the sustainability of renewable energy technologies can help minimize these impacts.

Solar micro grids are an additional solution which are self-contained power systems that utilize solar panels as the primary electricity source. They function independently or can connect to the main electrical grid for backup power or to sell excess energy.



Here's a breakdown of their key components and operation:

- **Solar Panels:** These convert sunlight into direct current (DC) electricity.
- **Inverters:** They convert the DC electricity from the solar panels into alternating current (AC) electricity, which is the type of electricity used in homes and businesses.
- **Energy Storage (Optional):** Batteries can store excess solar energy generated during the day for use at night or during peak demand periods.
- **Control System:** This intelligent brain of the micro grid monitors energy production, consumption, and battery storage levels. It ensures the micro grid operates efficiently and seamlessly switches between power sources if needed.

**Operation Modes:**

- **Grid-Connected:** In this mode, the micro grid operates primarily using solar power. Any excess electricity generated during the day can be fed back to the main grid for credits or sold to the utility company. If demand exceeds solar generation or if there's a power outage on the main grid, the micro grid can automatically draw power from the main grid to meet its needs.
- **Island Mode:** During power outages on the main grid, the micro grid disconnects and operates independently. The control system ensures a continuous flow of power using the available solar energy and stored energy in the batteries (if present).

**Benefits of Solar Micro grids:**

- **Energy Independence:** Micro grids offer a degree of energy independence from the main grid, providing a reliable power source during outages.
- **Reduced Reliance on Fossil Fuels:** By generating clean solar power, micro grids help reduce greenhouse gas emissions and dependence on fossil fuels.
- **Increased Resilience:** Communities with micro grids are less vulnerable to widespread blackouts that can affect the main grid.
- **Cost Savings (Potential):** Micro grids can potentially lower electricity bills by reducing reliance on the main grid and selling excess solar energy back to the grid.

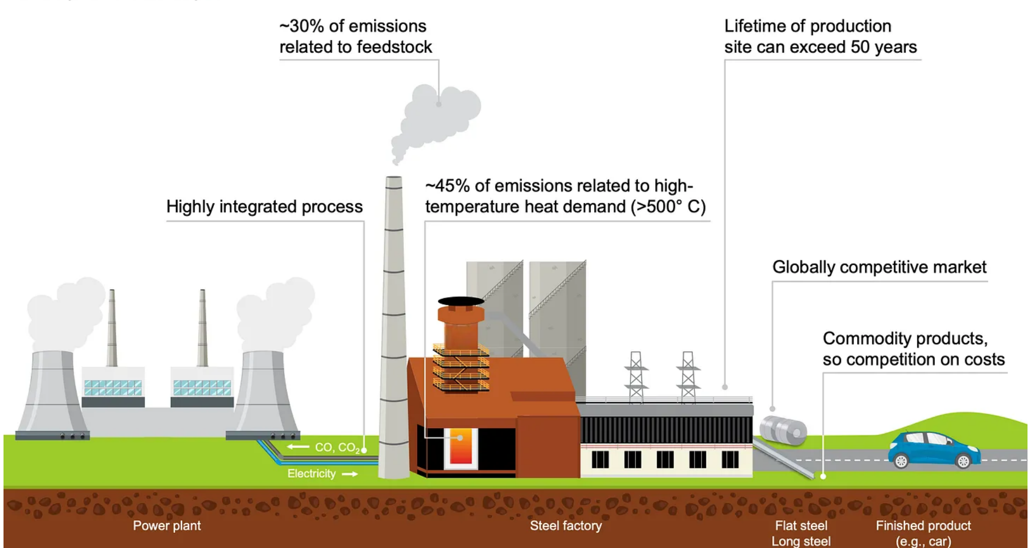
## Decarbonizing Industry

The production of essential industrial materials like cement, steel, ammonia, and ethylene is a major contributor to carbon dioxide (CO2) emissions.

- **Raw Material Impact (Feedstocks):** A significant portion, roughly 45%, of the CO2 released stems from the very nature of the raw materials used. Limestone in cement production and natural gas in ammonia production exemplify this phenomenon. These materials have inherent chemical properties that release CO2 during processing.
- **High-Heat Processes:** Another major contributor, at about 35%, is the burning of fossil fuels to generate the intense heat required for these industrial processes. This high-temperature environment is essential for various stages of production, but it comes at the cost of significant CO2 emissions.
- **Energy Consumption Beyond High Heat:** The remaining 20% of CO2 emissions arise from other on-site energy demands:
  - **Medium and Low-Temperature Needs:** Fossil fuels are still often burned to generate medium or low-temperature heat within these industrial facilities, contributing around 13% of the total CO2 emissions.
  - **Machine Operations:** Even the operation of machinery within the plants contributes its share, accounting for approximately 7% of the CO2 released.

Why are the steel, cement, ammonia, and ethylene sectors hard to abate?

Steel process example




SOURCE: IEA data from World Energy Statistics © OECD/IEA 2017 IEA Publishing; Enerdata: global energy and $CO_2$ data; expert interviews

## Strategies for Reducing Industry's Carbon Footprint

Electricity, the invisible power that fuels our modern lives, takes a fascinating journey before it reaches your outlets.

According to McKinsey, the following are our options for reducing our industry carbon footprint:

- **Reducing Demand:** Lowering the need for specific industrial products translates to decreased production and, consequently, CO2 emissions. For instance, lighter vehicles require less steel, and wood can sometimes be a suitable alternative to cement. Furthermore, promoting a circular economy by increasing recycling and reuse of materials like plastics and steel minimizes the need for virgin materials, leading to lower emissions.

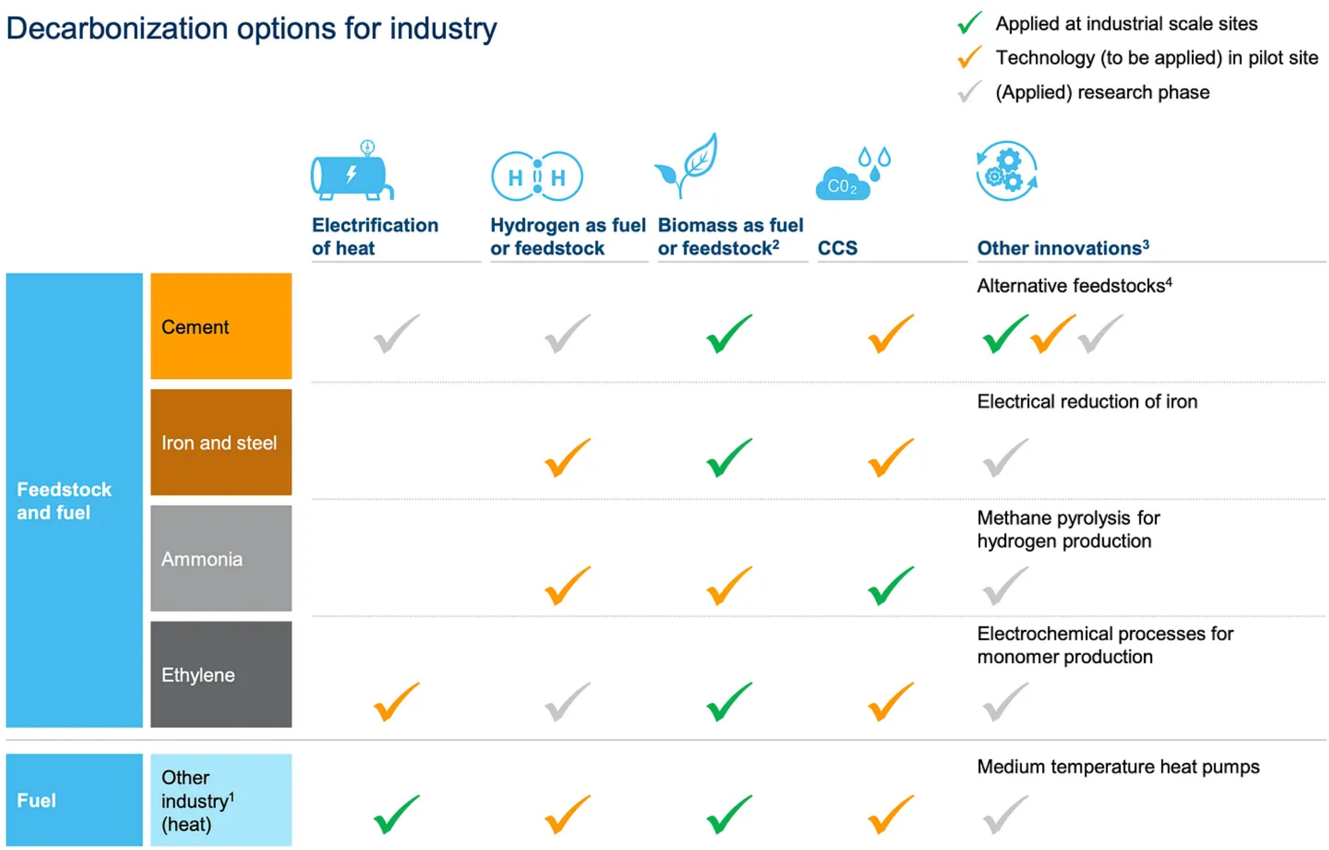
- **Energy Efficiency Boost:** Significant cuts in fuel consumption (15-20% across industries) can be achieved through improved energy efficiency measures. The potential for these gains varies depending on factors like region and facility type. Generally, developing regions have a larger potential for improvement compared to developed ones. By using less fossil fuel for manufacturing, overall CO2 emissions can be significantly reduced.

- **Electrifying Heat Generation:** Switching to electric furnaces, boilers, and heat pumps powered by clean electricity eliminates emissions associated with fossil fuel-based heating systems. This electrification process may necessitate changes in production methods. For example, electrifying ethylene production requires companies to install new electric furnaces and compressors.

- **Harnessing Hydrogen Power:** Hydrogen produced from zero-carbon electricity via water electrolysis can replace fossil fuels for heat generation and certain feedstocks, thereby lowering emissions. An example is decarbonizing ammonia production by using clean hydrogen instead of natural gas as a feedstock.

- **Sustainable Biomass Utilization:** Similar to hydrogen, sustainably sourced biomass can be a substitute for some fuels and feedstocks. Depending on the specific requirements, solid (wood, charcoal), liquid (biodiesel, bioethanol), or gaseous (biogas) forms of biomass can be used. For instance, some Brazilian steel producers utilize charcoal as a fuel and feedstock instead of coal, and European chemical companies are experimenting with bio-based naphtha for chemical production.

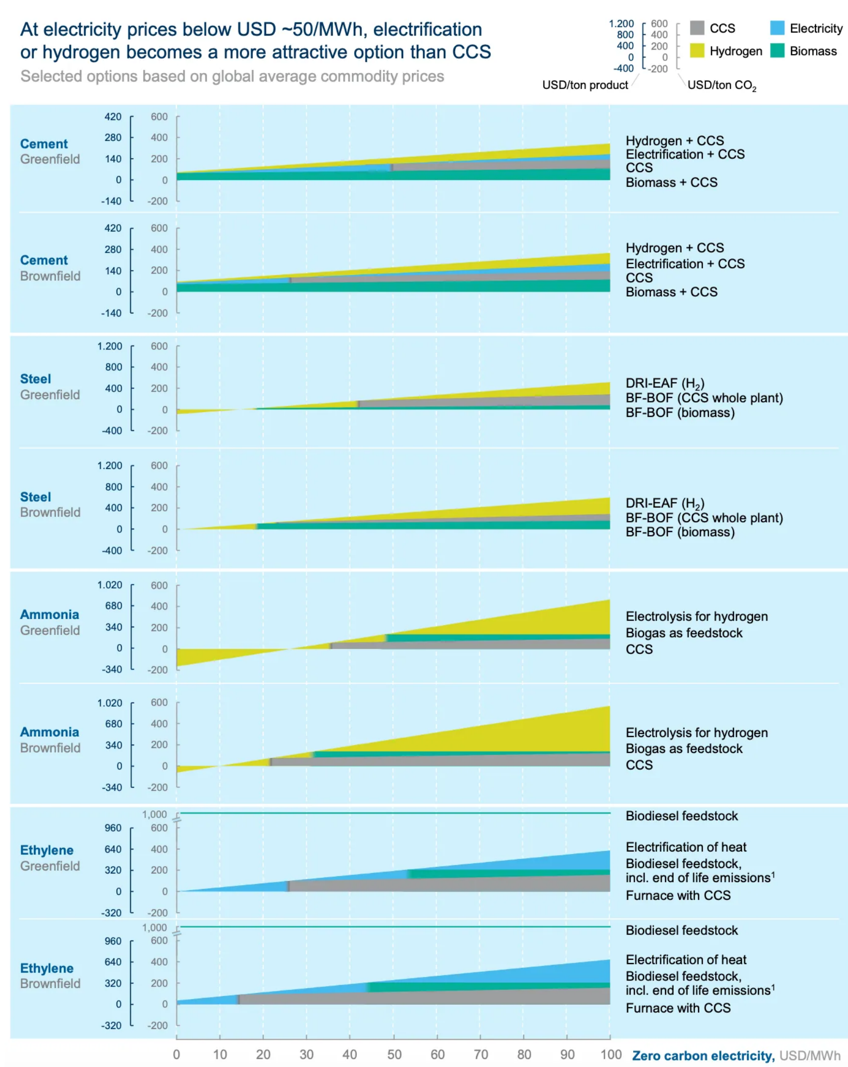
- **Carbon Capture Technologies:** These technologies capture CO2 from industrial exhaust gases, preventing its release into the atmosphere. Captured CO2 can then be either stored underground (carbon capture and storage - CCS) or utilized as a feedstock for other processes (carbon capture and utilization - CCU).
- **Emerging Innovations:** Beyond the strategies mentioned above, ongoing research is exploring alternative industrial processes that can further reduce CO2 emissions. This includes finding replacements for limestone in cement production to minimize process emissions and developing electrochemical processes that use electricity instead of heat for chemical reactions at high temperatures.




Source: McKinsey

## Carbon Capture: Storage vs. Utilization

While Carbon Capture and Storage (CCS) permanently isolates captured CO2 underground, Carbon Capture and Utilization (CCU) offers a different approach. CCU keeps captured CO2 out of the atmosphere by transforming it into valuable products. These can be feedstocks for various industrial processes, such as chemicals or fuels. Examples include the production of methane, polymers, or innovative materials like carbon fiber. This approach promotes a more circular carbon economy by keeping carbon in use.




Source: McKinsey

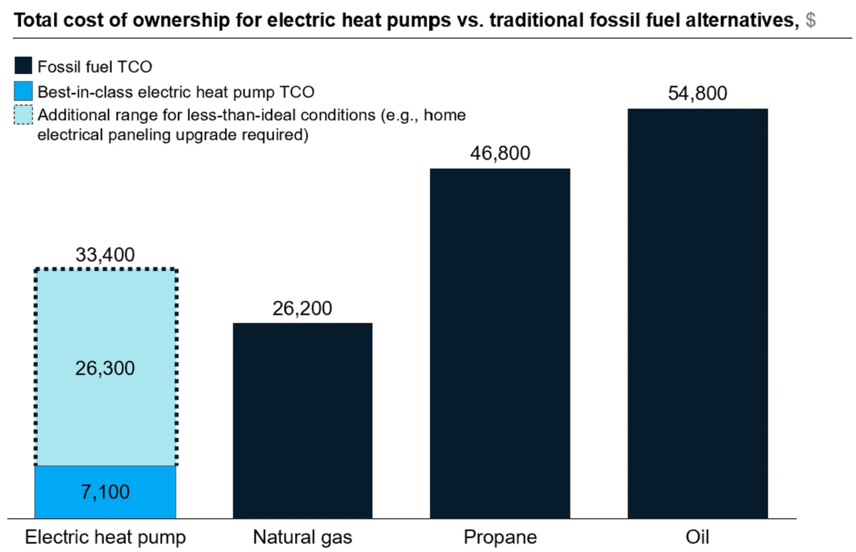
A key advantage of CCU over CCS is its potential economic benefit. By creating saleable products from captured CO2, CCU could make carbon capture more financially attractive. However, a recent study by CO2 Sciences and The Global CO2 Initiative highlights some challenges hindering CCU's development and commercialization.

The main hurdle lies in the **high energy consumption** associated with converting CO2 into usable chemicals. Hydrogen, a key component in this process, is often a major energy drain. This translates to high costs and a significant demand for clean electricity. Fortunately, advancements in catalyst technology, improved processing methods, and a **growing supply of affordable zero-carbon electricity** offer promising solutions to make CCU a more viable option in the future.

## Decarbonizing Buildings (Commercial & Residential)

The fight against climate change has placed a spotlight on the significant contribution buildings make to global carbon emissions. As the world collectively strives towards achieving net-zero emissions, various stakeholders are pushing for the decarbonization of buildings. This multi-pronged approach involves real estate investors who have made ambitious net-zero commitments for their portfolios. Policymakers are also playing a crucial role by establishing stricter emissions limits and regulations for new and existing buildings. Additionally, tenants are increasingly seeking out greener spaces, with energy efficiency being a major deciding factor when choosing a place to live or work.

Electrification of building systems is a key strategy for reducing emissions and achieving these net-zero goals. Traditionally, space and water heating systems have relied on fossil fuels like natural gas, releasing harmful greenhouse gases during combustion. However, advancements in electric heat pump technology have opened up a cleaner and more sustainable alternative. Heat pumps have become significantly more efficient and cost-competitive in certain markets, making them a viable solution for many building owners and developers. This shift towards electric heat pumps has the potential to dramatically reduce a building's environmental footprint and contribute to a greener future for our cities and communities.




Source: Harvard Business School

Transitioning building heating systems from fossil fuels to electricity has historically faced significant hurdles. These include the high cost and complexity of converting existing systems (steam, hot water, forced air, etc.) to electric alternatives. Additionally, in colder climates, fossil fuel heating has often been the more cost-effective option.

However, the tide is turning. Advancements in heat pump technology, coupled with more competitive costs for equipment, operation, and installation in certain markets, are making electric heat pumps a compelling option for building decarbonization.

These advancements translate into significant efficiency gains. Today's heat pumps can be 2.2 to 4.5 times more efficient than traditional gas furnaces. On a global scale, widespread adoption of heat pumps has the potential to slash $CO_2$ emissions by 3 gigatons per year. Furthermore, McKinsey analysis predicts that heat pumps could capture a massive share of the heating market, accounting for roughly 90% of new unit sales by 2050, compared to just 35% today.

## Decarbonizing Agriculture

Farming activities, including raising crops and livestock, generate greenhouse gas emissions in several ways:

- **Soil Management and Nitrous Oxide ($N_2O$):** Certain practices can increase available nitrogen in the soil, leading to $N_2O$ emissions. These practices include using synthetic or organic fertilizers, planting nitrogen-fixing crops, draining organic soils, and specific irrigation methods. In fact, soil management on agricultural lands contributes over half of the sector's total greenhouse gas emissions.

- **Cropland and Grassland Management:** While not directly covered here, it's important to note that managing croplands and grasslands can influence both emissions and removal of carbon dioxide ($CO_2$). These are accounted for in a separate category called Land Use, Land-Use Change, and Forestry.

- **Livestock Methane ($CH_4$):** Ruminant animals like cattle produce methane ($CH_4$) as part of their digestion, a process called enteric fermentation. This contributes to over a quarter of the sector's greenhouse gas emissions.

- **Manure Management:** The way livestock manure is handled also impacts $CH_4$ and $N_2O$ emissions. Different storage and treatment methods affect the amount of these gases released. In the United States, manure management is responsible for roughly 14% of the agricultural sector's total greenhouse gas emissions.

- **Other Sources:** While smaller contributors, additional agricultural emissions include $CO_2$ from applying lime and urea fertilizers, $CH_4$ from cultivating rice, and burning crop residues, which releases both $CH_4$ and $N_2O$.

## Decarbonizing Soil Management

**Nitrous oxide (N2O) can't be captured like CO2, so reducing emissions is key.** This can be achieved by minimizing nitrogen (N) levels in the soil, especially during times when N2O is most likely produced (warm, wet periods). Rainfall triggers emissions, but only when it fills enough soil pores (around 60% water). The amount of N2O released depends on the amount of available N, how quickly the soil dries out, and soil temperature. Soil type, fertilizer timing, and crop type all influence these factors.

### Reducing Nitrous Oxide Emissions from Fertilizer: Key Strategies

There are several strategies for reducing N2O emissions from fertilizers:

- **Enhanced Efficiency Fertilizers:** While promising in theory, some enhanced efficiency fertilizers haven't lived up to expectations. Urease inhibitors seem ineffective, while nitrification inhibitors show promise in reducing N2O. Polymer-coated fertilizers only work effectively in poorly drained soils.
- **Split N Applications:** This straightforward practice involves applying fertilizer in smaller doses throughout the growing season instead of a single large dose. This reduces the total amount of fertilizer needed and minimizes readily available N in the soil during periods of low crop uptake.
- **Cover Crops:** Planting cover crops, especially those that fix nitrogen (legumes), can help reduce N2O emissions. These crops capture leftover nitrogen from the soil after harvest and slowly release it back later, reducing overall fertilizer needs and N concentration in the soil.
- **Variable Rate N Management:** This advanced technique uses sensors or nitrogen-rich strips to assess crop N needs and adjust fertilizer application rates within a field. This ensures optimal N use by crops while minimizing the amount available for N2O formation. Sensor-based N management has been shown to increase N use efficiency by over 15%.

Combining these strategies, particularly variable rate N management with cover crops and split applications, offers the best potential for significant N2O emission reduction.

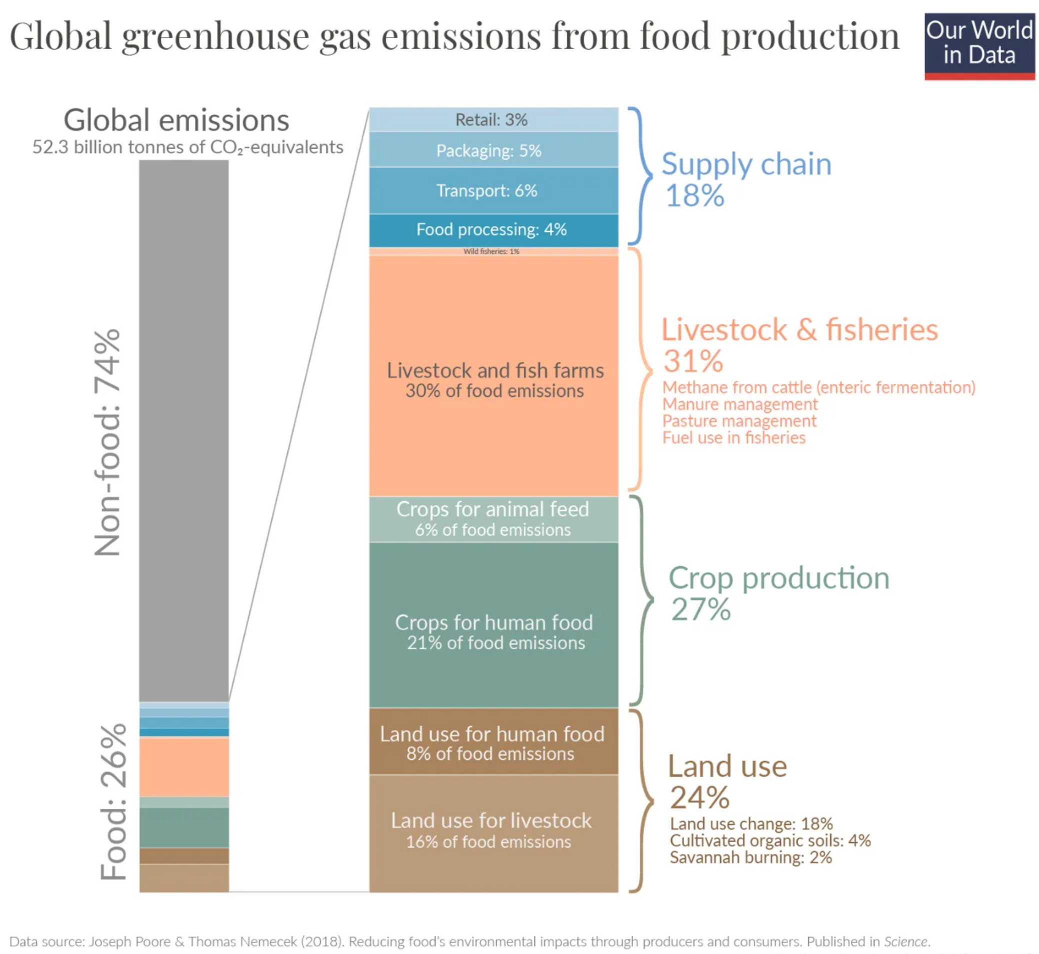
## Decarbonizing Livestock

Livestock and fisheries contribute roughly 30% of food emissions. This includes methane produced by ruminant animals like cattle during digestion, as well as emissions associated with manure and pasture management. Wild fisheries contribute a smaller portion, about 1%, primarily due to fuel consumption by fishing vessels.

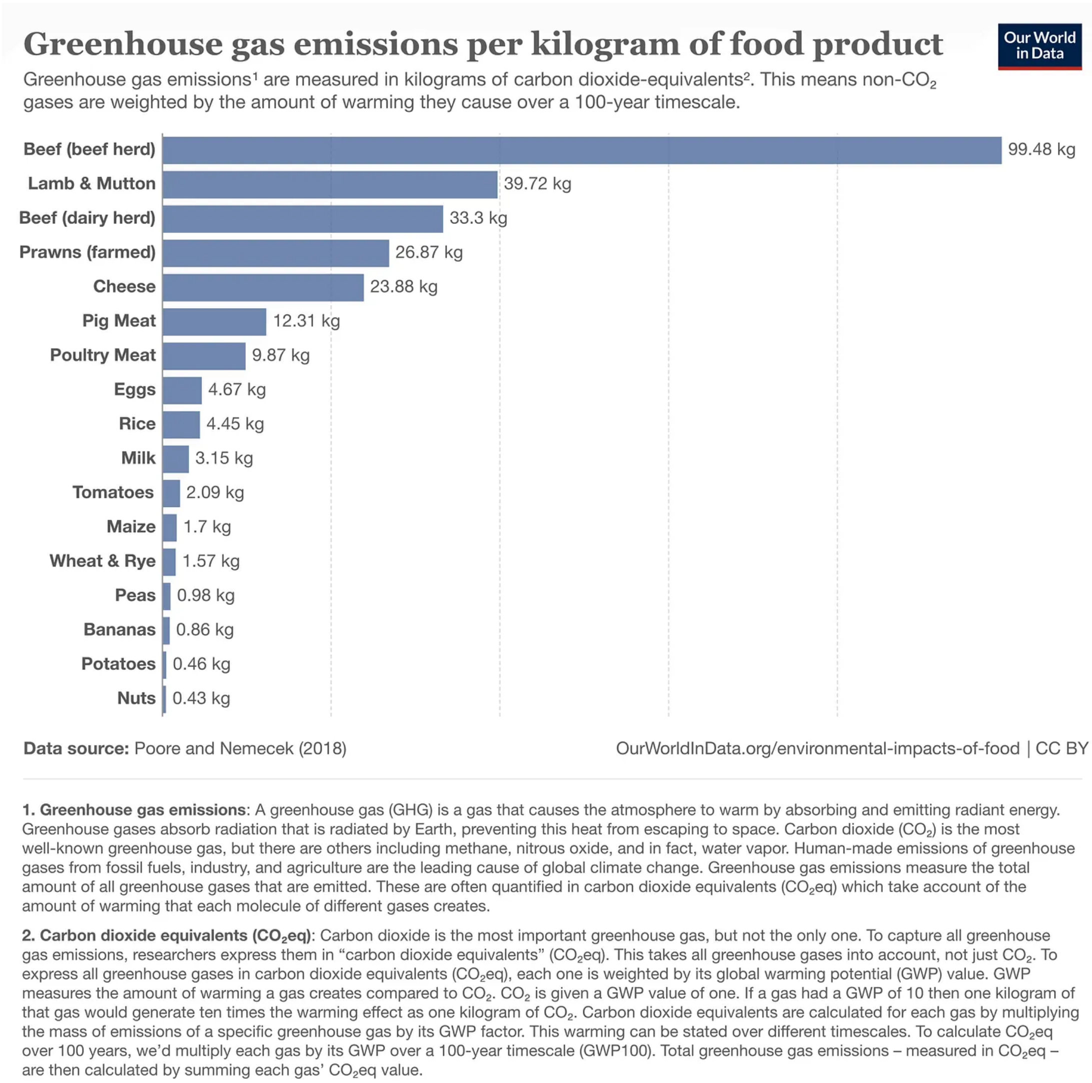
Crop production is another source of emissions, accounting for about a quarter (25%). This encompasses crops grown for both human consumption and animal feed.

Land-use change for agriculture generates 24% of food emissions. Interestingly, converting land for livestock production is twice as impactful (16%) as converting land for crops grown directly for human consumption (8%).

Finally, the various stages within the food supply chain, including processing, distribution, transport, packaging, and retail, contribute approximately 18% of food emissions.



The bulk of this is coming from beef consumption as can be seen below:




The solutions on how to fix this issue can be found below:

| Technical solution | Top abatement levers |
|---|---|
| Deploy next-horizon technologies | Methane inhibitors; direct methane capture aerobic rice; gene editing; microbiome |
| Boost crop efficiency | Pressurized irrigation and electrification of on-site machinery |
| Change rice planting[1] | Dry direct seed; rice paddy water; straw, sulfate fertilizers; varietal rice selection |
| Improve manure management | Plug flow, covered lagoon, and anaerobic; small-scale dome and complete mix anaerobic digestors |
| Change breeding | Genetic selection and breeding; growth promoters; health monitoring |
| Change feeding | Feed-mix optimization; feed grain processing; feed additives |

Source: McKinsey

### Curbing Livestock Emissions: The Promise of Feed Additives

Livestock contribute significantly to greenhouse gas emissions, particularly methane produced during digestion. However, new research offers a promising solution: feed additives.

Certain additives, such as seaweed and propionate precursors, can hinder methane formation within an animal's gut. Companies like DSM are developing such additives to address enteric fermentation (gut fermentation) in cows. Their additive, when added to cattle feed at a rate of one tablespoon per 250 pounds, demonstrably reduces methane emissions by 30% without compromising milk production. DSM submitted this innovation for approval in the European Union in 2022.

Seaweed as a feed additive is also gaining traction, with startups like Volta Greentech and Blue Ocean Barns working on scaling up its use for farmers. These advancements offer a potentially game-changing approach to mitigating the environmental impact of livestock production.

### Reducing Emissions at the Source: Genetic Approaches

Genetics play a significant role in methane emissions from ruminants, accounting for roughly 20% of their total output.

Traditional breeding methods have already shown promise. Existing commercial breeding programs can achieve reductions of 5% or more per animal, and targeted breeding within individual herds has demonstrated up to 20% variation in methane production.

Emerging technologies like CRISPR/Cas9 gene editing hold even greater potential. These techniques could streamline the development of new breeding strategies and allow for more precise targeting of genes that influence methane production. Synomics, a European company, is pioneering such an approach. Their analytics-driven selective breeding solution offers a cost-effective option for farmers seeking to reduce their environmental footprint.

By optimizing animal genetics, we can tackle methane emissions at the source, creating a more sustainable livestock industry.

### Fine-Tuning Diets: How Feed Optimization Lowers Emissions

Optimizing feed mixes offers a widely applicable strategy for reducing methane emissions in ruminant animals. This approach involves gradually transitioning their diet to include a higher fat content. Enteric fermentation, the digestive process responsible for methane production, slows down with a more fatty diet.

There's a growing interest in incorporating larger quantities of whole seeds, plant oils, or fat supplements into animal feed. Traditionally, the dry matter (DM) content of a ruminant diet is around 1.5 to 3.0% fat. Studies suggest this can be safely increased to 6.0% fat without compromising animal health. Each 1% increase in dietary fat content translates to a 4% reduction in methane emissions per animal. This method offers a scalable and practical way for farmers to contribute to a more sustainable livestock industry.

### The Road to Lower Emissions: Challenges and Opportunities

A McKinsey analysis suggests that adopting these technical solutions would require a significant upfront investment of $250 billion. However, the potential long-term benefits are considerable, with annual operating cost savings estimated between $20 billion and $40 billion.

Despite these promising possibilities, there are practical hurdles to overcome:

- **Fragmented Industry:** The agricultural sector is decentralized, making it challenging to implement widespread changes.
- **Limited Incentives:** Financial and regulatory incentives to encourage methane reduction are often lacking.
- **Animal Welfare Concerns:** New practices must prioritize animal well-being.
- **Low Awareness:** Many stakeholders may not be fully aware of the issue or potential solutions.
- **Monitoring Challenges:** Effective monitoring systems for methane emissions are often absent in many countries.

Furthermore, agriculture plays a critical role in supporting livelihoods and economic development globally, particularly for low-income populations. Farmers are understandably cautious about adopting practices that might reduce yields in the short term, even if they offer long-term environmental benefits.

## Targeting Concentrated Segments for Maximum Impact

Given the dispersed nature of agricultural production and the complex supply chain, focusing on specific segments could be the most effective strategy for methane abatement. Upstream and midstream players, such as distributors, seed producers, and cattle breeders, hold significant potential for implementing solutions. These groups could be responsible for roughly two-thirds of the mitigation efforts for animal methane emissions and about two-fifths for rice methane emissions. Enacting change within these concentrated segments might be more feasible compared to targeting millions of smaller or subsistence farming operations.

# PART 4 - GLOBAL CLIMATE POLICY

## A Long Road: Global Climate Policy and the Inflation Reduction Act

The fight against climate change has been a marathon, not a sprint. It's a decades-long journey marked by international cooperation, setbacks, and renewed efforts. Understanding this history provides essential context for the Inflation Reduction Act (IRA), a significant piece of US legislation aimed at curbing greenhouse gas emissions.

**Early Days: Setting the Stage (1960s-1980s)**

- **Scientific Consensus Emerges:** By the 1960s, scientists were increasingly raising alarms about human-caused climate change. The groundwork for international action was laid with the establishment of the World Meteorological Organization's (WMO) Integrated Global Observing System (IGOS) in 1985. IGOS aimed to create a comprehensive network to monitor climate-related changes across the globe.

- **First International Steps:** The 1972 Stockholm Conference on the Human Environment marked a pivotal moment, highlighting the need for coordinated action on environmental issues, including climate change. This conference brought together government representatives, scientists, and non-governmental organizations (NGOs) for the first time to discuss these pressing issues. The 1987 Montreal Protocol, addressing ozone depletion, offered a successful model for international collaboration. The Montreal Protocol demonstrated that international cooperation could effectively tackle global environmental challenges.

**The Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (1990s)**

- **A Global Framework:** The 1992 Rio Earth Summit, another major milestone, led to the establishment of the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC's main objective was to stabilize greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system. It established a framework for international cooperation to achieve this goal. The UNFCCC provided a crucial platform for ongoing negotiations and discussions on climate change mitigation and adaptation strategies.

- **Differentiated Responsibilities:** The UNFCCC acknowledged the historical responsibility of developed countries for greenhouse gas emissions and recognized the need for them to take the lead in mitigation efforts. This principle of "common but differentiated responsibilities and respective capabilities" (CBDR-RC) remains a cornerstone of international climate policy discussions.

- **Kyoto Protocol:** The 1997 Kyoto Protocol marked the first attempt at legally binding emission reduction targets for developed countries. The Kyoto Protocol set specific emission reduction targets for industrialized nations, hoping to curb their greenhouse gas emissions. However, the Kyoto Protocol faced challenges, particularly with the withdrawal of the United States in 2001, significantly weakening its effectiveness.

**Beyond Kyoto: The 21st Century and the Rise of Global Action**

- **A Period of Stalemate:** The early years of the 21st century saw limited progress on a global scale. Geopolitical tensions and a lack of consensus on ambitious emission reduction targets hampered international efforts. The failure of the 2009 Copenhagen Climate Change Conference highlighted the difficulty of reaching a consensus on more aggressive emission reduction targets. The Copenhagen conference aimed to establish a successor agreement to the Kyoto Protocol but ultimately fell short of expectations.

- **Paris Agreement (2015):** A turning point came with the adoption of the Paris Agreement in 2015. This landmark agreement shifted the focus to nationally determined contributions (NDCs), where countries set their own emission reduction targets and report their progress. The Paris Agreement aimed to hold the increase in global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the increase to 1.5°C. This shift towards a more flexible and bottom-up approach was seen as crucial to garnering broader international support. The Paris Agreement has been widely praised for its emphasis on transparency, accountability, and the need for regular review and improvement of NDCs.

**The Inflation Reduction Act (IRA) in the US Context**

- **A Historic Investment:** Passed in 2022, the IRA represents the most significant US climate legislation to date. It aims to invest $369 billion over the next decade in clean energy and climate change solutions. These investments are expected to significantly reduce US greenhouse gas emissions and bring the country closer to achieving its NDCs under the Paris Agreement. The IRA marks a significant shift in US climate policy and is expected to have a ripple effect on global efforts.

❖ **Focus on Clean Energy and Innovation:** The IRA incentivizes clean energy technologies like solar, wind, and electric vehicles. It also provides funding for research and development of new technologies crucial for a low-carbon future. By accelerating the development and deployment of clean energy technologies, the IRA can not only help the US reduce emissions but also make these technologies more affordable and accessible for other countries.

**The Inflation Reduction Act's Impact Across Industries**

The Inflation Reduction Act (IRA) marks a turning point in US climate action. Its historic $369 billion investment in clean energy and climate solutions promises to reshape various industries, accelerating the transition to a low-carbon future. Let's explore the specific ways the IRA will impact key sectors:

**Manufacturing:**

❖ **Clean Tech Powerhouse:** The IRA offers a powerful incentive for the domestic production of clean energy technologies. Tax credits and grants will make it more affordable to manufacture solar panels, wind turbines, and electric vehicle (EV) batteries in the US. This will create a domestic clean tech manufacturing boom, fostering job growth and strengthening the US clean tech supply chain. Reduced reliance on foreign-made clean tech components will also enhance national security and economic resilience.

❖ **Sustainable Materials Focus:** As demand for clean energy technologies surges, so will the need for the materials they're built from. The IRA can incentivize investments in sustainable and ethical mining practices to meet the growing demand for lithium (used in batteries) and rare earth elements (used in magnets) for clean technologies. Responsible sourcing practices can ensure minimal environmental impact and fair labor conditions throughout the supply chain.

**Clean Energy:**

❖ **Renewable Renaissance:** The IRA's tax credits and production incentives will significantly reduce the cost of deploying solar, wind, and other renewable energy sources. This will make renewable energy projects more financially attractive, accelerating the transition away from fossil fuels and reducing dependence on volatile global oil prices. A cleaner electricity grid powered by renewables will contribute to improved air quality and public health.

❖ **Grid Modernization Gets a Boost:** The IRA recognizes the importance of a modern and efficient electricity grid to integrate the variable nature of renewable energy sources like solar and wind. Investments in grid modernization projects will ensure the grid can handle fluctuations in renewable energy production, maximizing their effectiveness and minimizing reliance on fossil fuel backup plants.

**Energy Storage: The Key to Unlocking Renewables' Potential:**

- **Empowering Storage Solutions:** The IRA acknowledges the critical role of energy storage in enabling a renewable-powered grid. Tax credits and grants will propel the development and deployment of energy storage technologies like batteries and pumped hydro storage. These advancements will allow for storing excess renewable energy generated during peak production periods and releasing it back into the grid when needed, ensuring a reliable and stable electricity supply.

- **Long-Duration Vision:** The IRA specifically incentivizes investment in long-duration storage solutions. These technologies can store large amounts of renewable energy for extended periods, crucial for mitigating the intermittency of solar and wind power and ensuring grid stability during periods of low renewable energy production. Advancements in long-duration storage will pave the way for a truly 24/7 clean energy grid.

**Electric Vehicles: Electrifying Transportation:**

- **Making EVs More Affordable:** The IRA extends and expands tax credits for consumers purchasing new and used electric vehicles. This financial incentive will make EVs more accessible to a wider range of consumers, accelerating the adoption of electric mobility and reducing greenhouse gas emissions from the transportation sector, a major contributor to climate change.

- **Charging Infrastructure Buildout:** The IRA allocates significant funding for the development of a national network of electric vehicle charging stations, addressing a major concern for potential EV buyers. This infrastructure buildout will alleviate "range anxiety" – the fear of running out of power before reaching a charging station – and further accelerate the shift towards electric vehicles. A robust charging network will encourage long-distance travel with EVs, promoting a cleaner transportation landscape.

**Critical Materials: Securing a Sustainable Supply Chain:**

- **Domestic Sourcing Strategy:** The IRA incentivizes domestic mining and processing of critical materials like lithium and rare earth elements, essential for clean energy technologies. This will reduce reliance on foreign sources for these materials, lessening vulnerability to supply chain disruptions and geopolitical tensions. A robust domestic critical materials supply chain will ensure a stable and secure foundation for the clean energy transition.

- **Recycling Revolution:** The IRA promotes research and development of recycling and reuse technologies for critical materials. This can create a more circular economy for these resources, minimizing environmental impact from mining and reducing dependence on virgin materials. Advancements in recycling will ensure the long-term sustainability of the clean energy transition.

**Carbon Capture: Capturing Emissions and Looking to the Future:**

- **Early-Stage Technology Gets a Push:** The IRA provides tax credits for capturing and storing carbon emissions from power plants and industrial facilities. This financial support can help accelerate the development and deployment of carbon capture technologies, particularly for hard-to-decarbonize sectors like steel and cement production. While carbon capture is still in its early stages, the IRA's investment signifies its potential as a valuable tool in mitigating emissions.
- **Direct Air Capture:** A Glimpse into the Future: The IRA shows initial support for research and development of direct air capture.

# PART 5 - PUBLIC MARKET INVESTMENT OPTIONS

While the public markets offer numerous options for investing in the energy transition, some companies might be all "talk and no action" – lacking strong fundamentals. Here at Seeking Winners, we're not just about sustainable investments. We focus on high-quality companies that deliver strong returns on invested and reinvested capital. These companies also have long-term growth potential and demonstrate shareholder alignment through significant insider ownership.

To achieve this, I've teamed up with **The Compounding Tortoise.** Together, we'll each showcase a portfolio company that exemplifies a top-notch sustainable investment.

## Seeking Winners - Topicus - Using Tech to Decarbonize Buildings

Making our homes greener is crucial to fight climate change, lower energy bills, and address housing issues. Economic conditions are keeping people in their current homes, which is a chance to make them more sustainable. The good news is that banks and the government are offering money to help pay for these improvements. This creates a push for faster eco-friendly home upgrades. The missing piece was a smooth process for lenders, homeowners, government agencies, and contractors to work together. This gap is filled by a new, user-friendly online platform designed specifically for lenders in the sustainability field.

Greener homes, higher value, lower energy costs: Sounds like a win-win! Low savings rates and high energy bills are motivating many homeowners to invest in sustainable upgrades. These upgrades not only make their home more attractive to buyers with a better energy rating, but also bring down their energy costs.

Unfortunately, the process for making these changes can be confusing. People have many questions, like what subsidies are available, if they can increase their mortgage to cover the costs, and where to find a reputable solar panel installer. This complexity can discourage homeowners from making these improvements.

**Topicus**, a company known for simplifying processes in healthcare, education, finance, and social services, is stepping in with a clever tech solution. Topicus Connected Finance, their financial services division, has developed a one-of-a-kind platform to streamline the sustainability process.

This user-friendly platform walks homeowners through the process in just six steps, showing them available options, costs, and potential return on investment. The platform gathers data on the property from various sources like land registries and tax offices. The lender can then add their specific rates and products, allowing for immediate application validation. With a validated application, loan approval is practically guaranteed.

**Thinking of greening up your home?** This platform cuts through the confusion and gets you there in six easy steps, all through your bank or lender's website.

- **Quick Check:** See if your property qualifies for sustainability upgrades.
- **Home Snapshot:** Get a quick overview of your home's current value, energy costs, and energy efficiency rating.
- **Greening Options:** Let the platform know what eco-friendly improvements you've already made (like insulation) and explore additional options like solar panels or heat pumps.
- **Financing Fit:** Pick your preferences and the platform will suggest financing options. Tell it your down payment amount and how long you'd like to spread out the loan. You can use a mortgage, a government energy-saving loan, or even combine them, and it factors in any available subsidies (up to 30%). Need a new energy rating? The platform guides you through that too, including an optional visit from a certified consultant.
- **All Set? Review and Submit:** Take a final look at your plan and choose to submit the application yourself or with help from an advisor.
- **Beyond Financing:** This platform goes the extra mile. It connects you with "De Energiebespaarders" - a network of trusted contractors for sustainability measures. Get instant quotes for the upgrades you've chosen.

**What makes this platform unique?** It's a win-win for everyone:

- **Homeowners:** Easy-to-use process, clear choices, and connection to pre-vetted contractors.
- **Lenders:** More opportunities for sustainable loans in their portfolios.
- **Advisors:** Faster and smoother client financing applications.
- **The Environment:** Speeds up progress towards those green goals set out in the Paris Agreement.

By simplifying the entire process, the Topicus Connected Finance platform makes sustainable home improvements accessible and efficient for everyone.

Topicus, on top of helping decarbonize buildings also packs a punch with the fundamentals. I estimate they have average return on investment capital around 27% over the past two years and can generate 20% over the next decade.

The company has significant insider ownership and is not dilutive to shareholders, which is fantastic. The growth trajectory for the company to continue to acquire VMS businesses and growth organically in the 4-6% range should make this a true high quality compounder over time.

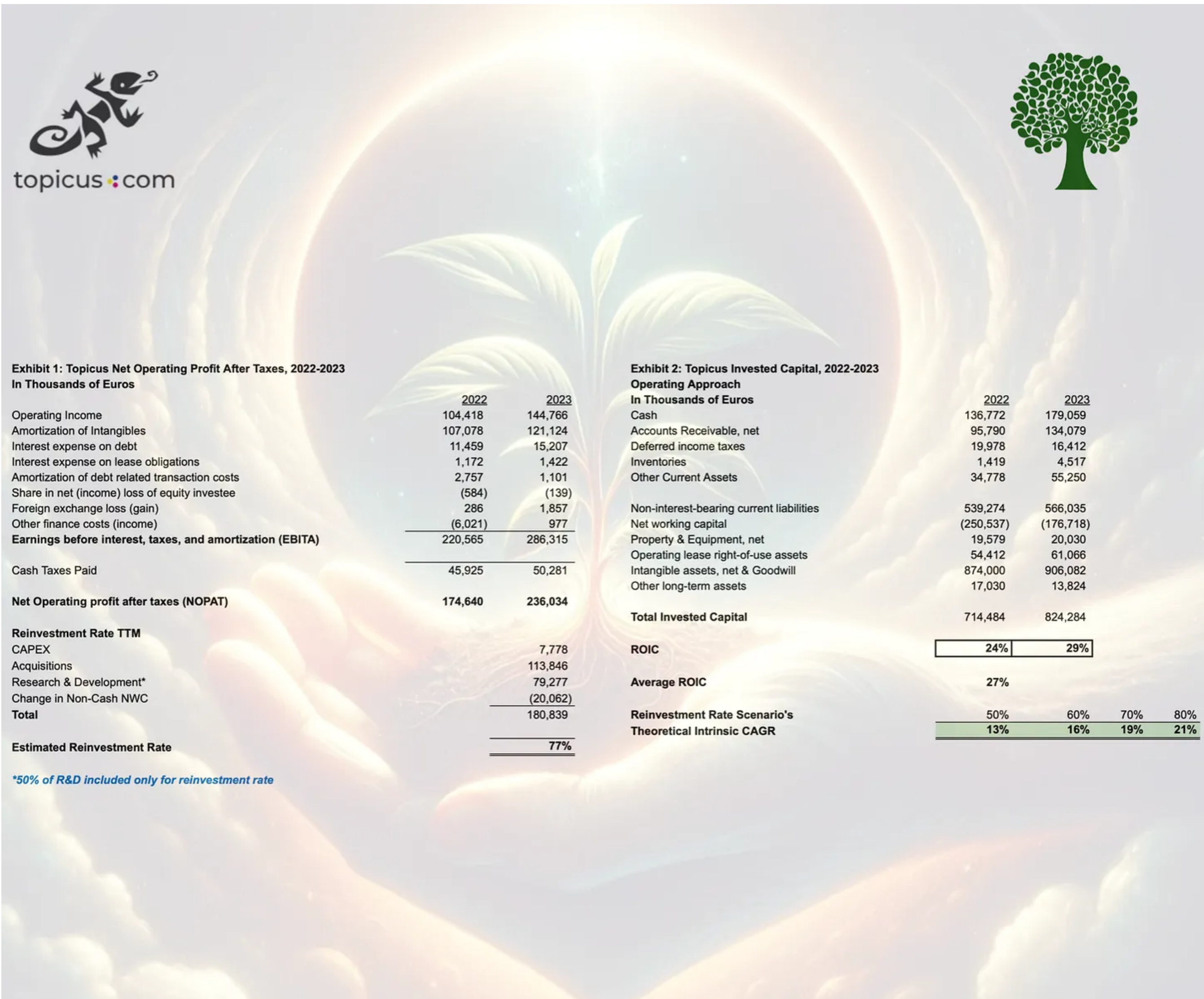



**Exhibit 1: Topicus Net Operating Profit After Taxes, 2022-2023**
**In Thousands of Euros**

| | 2022 | 2023 |
|---|---|---|
| Operating Income | 104,418 | 144,766 |
| Amortization of Intangibles | 107,078 | 121,124 |
| Interest expense on debt | 11,459 | 15,207 |
| Interest expense on lease obligations | 1,172 | 1,422 |
| Amortization of debt related transaction costs | 2,757 | 1,101 |
| Share in net (income) loss of equity investee | (584) | (139) |
| Foreign exchange loss (gain) | 286 | 1,857 |
| Other finance costs (income) | (6,021) | 977 |
| **Earnings before interest, taxes, and amortization (EBITA)** | 220,565 | 286,315 |
| Cash Taxes Paid | 45,925 | 50,281 |
| **Net Operating profit after taxes (NOPAT)** | **174,640** | **236,034** |
| **Reinvestment Rate TTM** | | |
| CAPEX | | 7,778 |
| Acquisitions | | 113,846 |
| Research & Development* | | 79,277 |
| Change in Non-Cash NWC | | (20,062) |
| **Total** | | 180,839 |
| **Estimated Reinvestment Rate** | | **77%** |

**50% of R&D included only for reinvestment rate*

**Exhibit 2: Topicus Invested Capital, 2022-2023**
**Operating Approach**

| **In Thousands of Euros** | 2022 | 2023 | | |
|---|---|---|---|---|
| Cash | 136,772 | 179,059 | | |
| Accounts Receivable, net | 95,790 | 134,079 | | |
| Deferred income taxes | 19,978 | 16,412 | | |
| Inventories | 1,419 | 4,517 | | |
| Other Current Assets | 34,778 | 55,250 | | |
| Non-interest-bearing current liabilities | 539,274 | 566,035 | | |
| Net working capital | (250,537) | (176,718) | | |
| Property & Equipment, net | 19,579 | 20,030 | | |
| Operating lease right-of-use assets | 54,412 | 61,066 | | |
| Intangible assets, net & Goodwill | 874,000 | 906,082 | | |
| Other long-term assets | 17,030 | 13,824 | | |
| **Total Invested Capital** | 714,484 | 824,284 | | |
| **ROIC** | **24%** | **29%** | | |
| **Average ROIC** | **27%** | | | |
| **Reinvestment Rate Scenario's** | 50% | 60% | 70% | 80% |
| **Theoretical Intrinsic CAGR** | **13%** | **16%** | **19%** | **21%** |

## The Compounding Tortoise - Linde - Making Our World More Productive

Being at the heart of the sustainable economy, Linde helps its customers decarbonize their assets in a variety of end markets with the ultimate goal of making our world more productive.

Linde plays a key role in our everyday lives. Simply put, Linde produces (almost entirely in-house), distributes, and sells industrial gases to a variety of sectors such as healthcare, food & beverage, energy, mining, etc. We've highlighted Linde in our most recent deep dive for investors interested in steady compounding through a business model that has stood the test of time. *https://thecompoundingtortoise.substack.com/p/deep-dive-linde-plc*

The production of gases requires significant amounts of electricity. When such electricity is generated using hydrocarbons, the multinational is penalized for those indirect emissions called Scope 2 emissions. When it comes to decarbonization, there are three pillars:

- Decarbonization of Linde.
- Ensuring our customers' ability to decarbonize.
- The new market opportunities.

Linde is planning to invest around $50 billion in clean energy over the next decade. Decarbonizing Linde is about recognizing that it has Scope 1 and 2 emissions. It feels strongly about the sustainability goals – a 35% reduction in absolute emissions by 2035 and our ambition to be climate neutral by 2050. Those targets got a meaningful uplift in the fall of 2021.

As of today, LIN has a pipeline of approximately 200 decarbonization projects with an expected $8 to $10 billion CAPEX, a range that's probability-weighted. Many of the proposed clean energy projects which are not in the pipeline as of yet (and definitely not in the project backlog) won't proceed, as they simply don't meet LIN's criteria in the first place. Conservative quality-investors should definitely cheer that pickiness. In February 2023, Linde entered into a long-term supply agreement to provide clean hydrogen and other industrial gases to OCI's new world-scale greenfield blue ammonium nitrate plant in Beaumont Texas.The facility will be built, owned and operated by Linde and will include autothermal reforming with carbon capture and a large air separation plant. The new facility will be integrated into Linde's extensive Gulf Coast industrial gas infrastructure and will provide clean hydrogen and nitrogen for OCI's 1.1 million tonnes per annum blue ammonia plant. This will be the first greenfield facility of this size to come on-line in the

United States. This is a particularly important project as it highlights a well-established off-take model, which its CEO believes will allow for significant progress to be made on the path to sustainability – and has been proven throughout the gases industry.

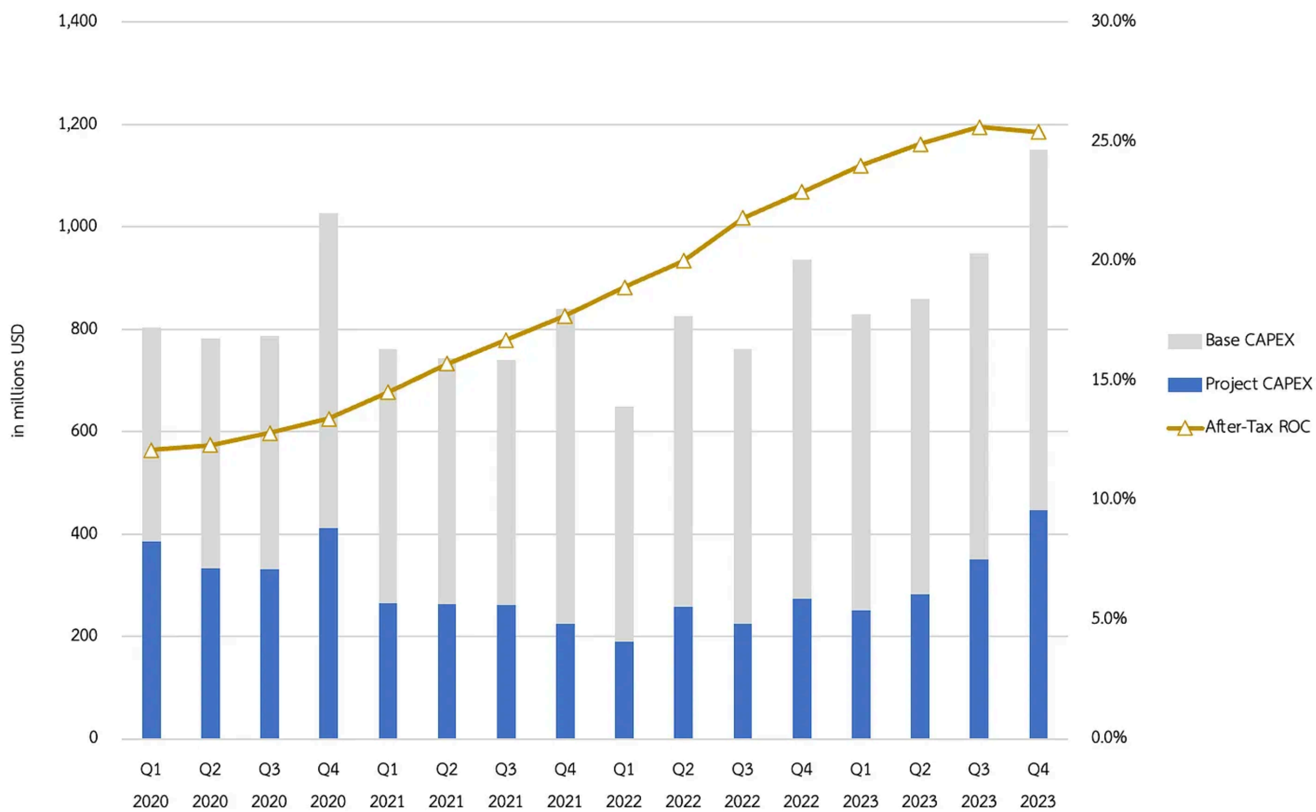
For now, Lamba believes it's appropriate to focus hydrogen with low carbon intensity that comes from the generation of hydrogen using carbon capture and sequestration. This technology is scalable and available at scale today. Linde can undertake world-scale projects to make low carbon intensity hydrogen available for industrial applications. Lamba sees this as a stepping stone to what he calls "renewable hydrogen." Renewable hydrogen is hydrogen based on electrolyzer-based electrolysis that uses renewable energy. There are a few things that need to happen before renewable hydrogen can be commercially viable. First, electrolysis technology needs to mature, especially PEM electrolysis, to a point where it has reliable and affordable operational capability that is available at scale, which should happen within a 5 to 7 year window. There are new entrants in clean energy by the day and it remains. Many of whom are non-traditional players in the hydrogen space and we believe that only leading players with an economic rationale will thrive.

From an investor point of view, Linde has been a great investment over the past years. Given the persistent inflationary pressures, geopolitical events and new emerging trends in the semiconductor space (electronics account for 9% of sales), Linde is well positioned to remain an investment for all seasons. We believe that its management team will continue to do what they do best: delivering industry-leading Return on Capital, operating margin and cash flow performance. We would go even further and say that Linde's business model benefits from increased volatility as economic shocks have recently widened the performance gap with its competitors. Linde's underlying capital intensity is much lower than what most people realize, as evidenced by its clear project backlog criteria, small incremental investments and strong presence in packaged gases.

By serving many industries with an essential commodity/service end market, the multinational is less prone to economic shocks and roughly 65% of its end markets are labeled as "defensive."

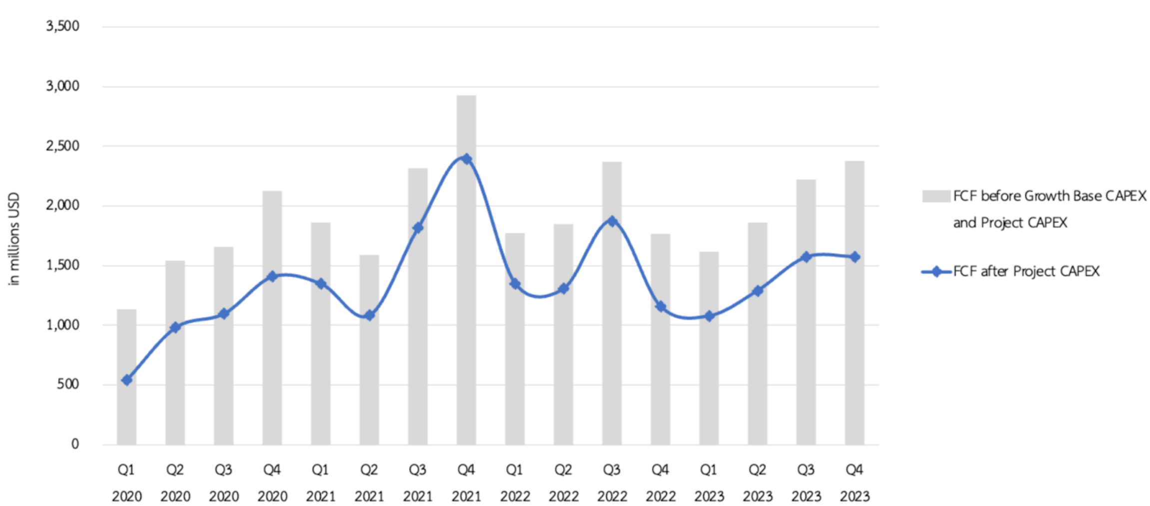
On which metrics does Linde stand out compared to its nearest peers? Return on Capital, stringent backlog criteria (contractual agreement, fixed payment structure and a customer cash deposit), CAPEX efficiency and cash flow generation (OCF), just to name a few.

At the end of 2023, ROC started plateauing a little bit as Linde is now embarking on more capital intensive initiatives (primarily in the clean energy space for which it gets tax credits) and because of a normalizing working capital situation related to the engineering business where contract liabilities continued to shrink from the FY21 record levels. However, given the structural productivity and pricing levers, we expect ROC to reach new highs by the end of this fiscal year. Stated differently, NOPAT should continue to grow faster than Linde's total capital base.




Source: The Compounding Tortoise & Company Filings

Positive free cash flow after all growth investments and even positive cash flow after paying for the dividends: that's where Linde stands out.




Source: The Compounding Tortoise & Company Filings

During periods of stock market volatility, it had the tendency to sweep some additional debt funding towards share repurchases, a trend we expect to continue. Its management team (with significant stock ownership) is focused on what it can control and prudent capital allocation has been one of Linde's key operating rhythms for multiple decades.

Over the past years, LIN has surprised us many times and the explicit capital allocation priorities should continue to serve it well, especially against the current macroeconomic backdrop. Admittedly, the stock isn't trading at cheap multiples but one should not lose sight of its consistent outperformance over the past five years. While history doesn't repeat itself, it oftentimes rhymes and its longevity should continue to deliver satisfying returns going forward.

# PART 6 - CONCLUSION

As highlighted in the research above, there is roughly $4trillion USD needed to reach net zero by 2030 with ongoing investments needed in CAPEX and emerging technologies. This presents plenty of options for investors, but also presents risks of fad investments that we don't want our readers to get caught up in.

**Seeking Winners & The Compounding Tortoise** are all about quality investments and we both believe in maintaining that same quality focus in when investing in the energy transition. We encourage our readers to look within your portfolio first and you may find that one or more of your current portfolio companies is already an indirect play on the energy transition. For example, from my portfolio, **Amazon** is making great strides in this area as shown in the graphic below:

| Goal | 2022 Progress | Status |
|---|---|---|
| **Carbon**[1] | | |
| Reach net-zero carbon emissions across Amazon by 2040. | 71.27M metric tons $CO_2e$*<br>93.7 $gCO_2e$/$GMS | → |
| Through The Climate Pledge, inspire and empower others to join us on a mission to reach net-zero carbon emissions by 2040. | 396 signatories | → |
| 100,000 Rivian electric delivery vans on the road by 2030. | 2,600+ Rivians | → |
| 10,000 electric vehicles (EVs) in our India delivery fleet by 2025. | 3,800+ EVs | → |
| **Renewable Energy** | | |
| Power our operations with 100% renewable energy by 2030. | 90% renewable electricity | → |
| Invest in wind and solar farm capacity equal to the energy use of Echo, Fire TV, and Ring devices worldwide by 2025. | 100% capacity procured | ✓ |
| **Packaging** | | |
| Make Amazon device packaging 100% recyclable by 2023. | Achieved for 79.5% of product launches | → |
| **Waste** | | |
| Reduce food waste by 50% across U.S. and Europe operations by 2030. | 82M meals donated globally | → |
| **Water** | | |
| Achieve water positivity for Amazon Web Services by 2030. | Goal set in 2022 | → |

Source: Amazon 2022 Sustainability Report

If you're interested in the global energy transition, have any questions, or any interesting investment options; please share this article, like and comment and I'll be sure to get back to you as soon as possible.

Yours sincerely,

*Seeking Winners*

# SUGGESTED READING

### From Product to Platform

SEEKING WINNERS • APR 9

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### From Test Tubes to Turbine Blades

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### Q1 2024 - Seeking Winners Quarterly Letter

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### Evolution (EVO)

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