THE INEVITABILITY OF
ENERGY TRANSITION
PAPER

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Throughout human history, energy transition addressed how the humankind used energy for its needs and reconciled it with the social, environmental, and economic needs.

In most cases transitions and shifts between major energy sources lasted over a century or longer and were encouraged by resource scarcity or higher costs. However, technological advancement and innovations like the steam engine or the wide-scale use of electricity, were also powerful drivers for these transitions.

Today, we can see energy transition spurred by deep changes to energy supply, demand, and prices, while aiming to reduce energy-related greenhouse gas emissions through various forms of decarbonization.

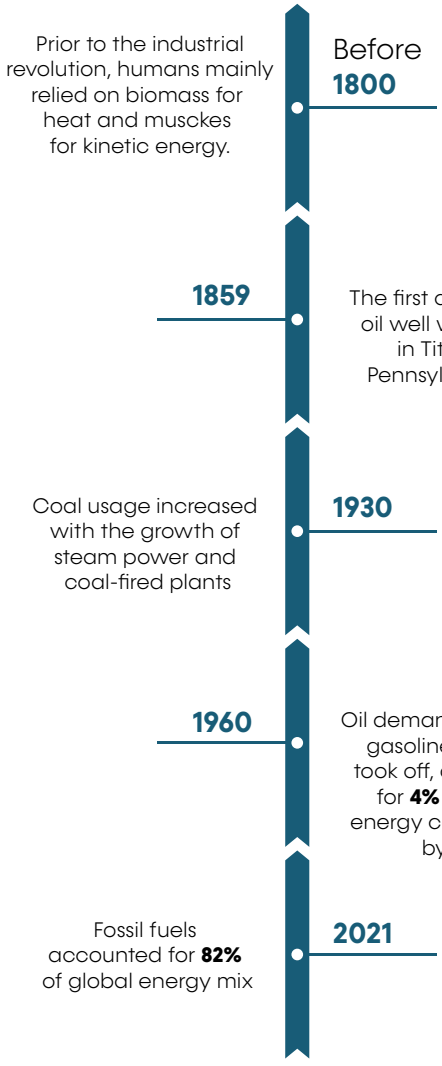
HISTORY OF ENERGY TRANSITION

Over the past two centuries, humans have come to rely on ever-increasing amounts of energy to fuel their growing numbers and improve their standards of living. On the one hand, this increased demand has led to remarkable shifts in the patterns of energy production and consumption; On the other hand, the simplest form of energy production remains essential to our societies.

This figure demonstrates the changing pattern of primary energy consumption over 1800-2021. Pre 1800, the dominant energy source was biomass extracted from animal residues, wood, agricultural crop residues, etc. One of the main energy transitions started when Great Britain began mining coal during the Elizabethan era. Another important energy transition followed the commercial discovery of crude oil in Pennsylvania in 1859.

In the early 1900s, fossil fuels-represented in coal, oil & gas-came side by side with biomass. For instance, in 1930, coal usage increased with the growth of steam power and coal-fired plants. In the mid 1900s, oil demand surged as gasoline vehicles took off, accounting for 4% of global energy consumption by 1970.

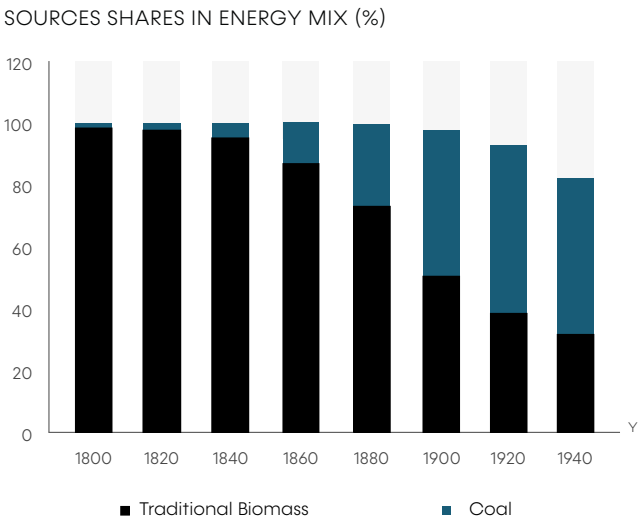
GLOBAL PRIMARY ENERGY CONSUMPTION BY SOURCE 1800 - 2021



1. COAL ENERGY TRANSITION

Post 1800, coal's share in the energy mix rose drastically and by 1900, it constituted around half of the world's energy mix; and half still came from biomass. In 1940, the share of coal in the energy mix surged by 2882% while the share of traditional biomass retreated by 68% compared to those in 1800.

COAL ENERGY TRANSITION

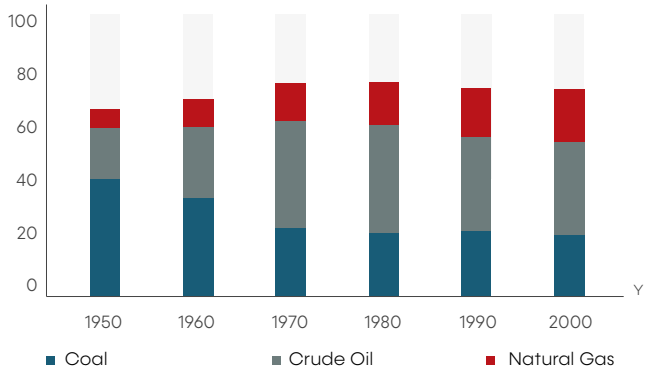


2. THE RISE OF OIL AND GAS

Between the 1940s and 1980s, the industrialized world gave the chance to oil and gas to rapidly increase their share in the global energy mix. In 1950, oil & gas shares accounted for about 26% of the energy mix, yet these shares continued to increase to hit 57% in 1980. In 2020, the share of oil and gas in the energy mix remarkably rose by 84% & 170%, respectively, compared to those in 1950, while coal share drew back by 49%.

THE RISE OF OIL AND GAS

SOURCES SHARES IN ENERGY MIX (%)



TODAY'S ENERGY TRANSITION

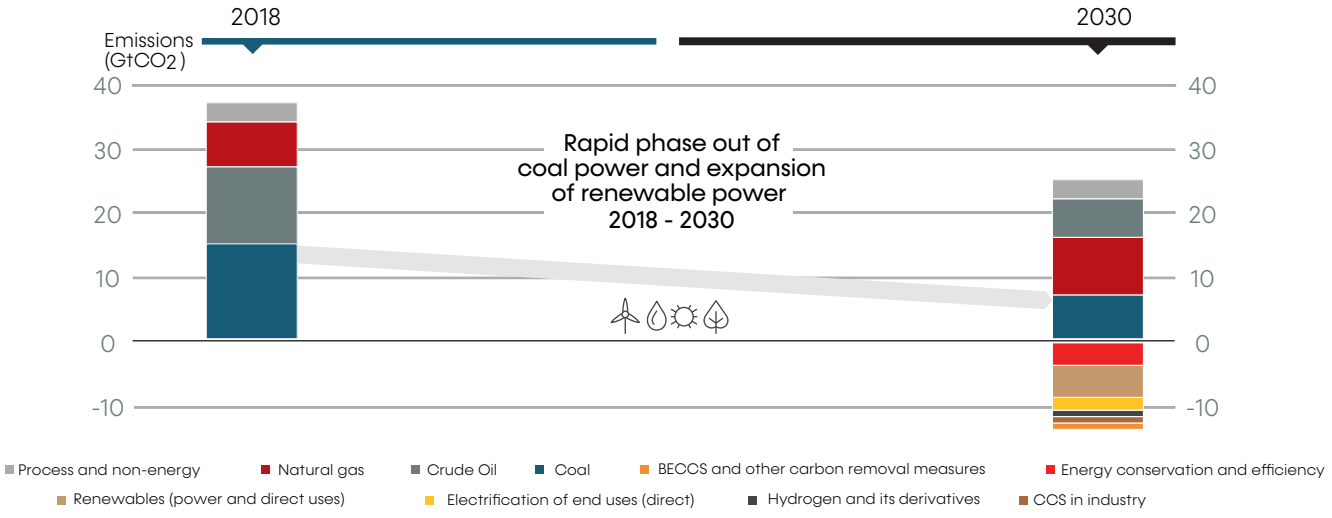
1. KEY DRIVERS

High fossil fuel prices, energy security concerns and the urgency of climate change underscore the pressing need to move faster to a clean energy system. However, the energy transition to more sustainable energy production won't happen by simply abandoning fossil fuels all at once. The process of elimination will have to be gradual and carefully handled in order to guarantee grid stability, resilience and efficiency.

The key to effecting this change is electrification: gradually replacing technologies that use fossil fuels with technologies that use electricity only from renewable sources in all sectors, from home cooking to heating to transportation. This will also reduce air pollution in cities and, thanks to the digitalization of the grids, energy efficiency will improve dramatically.

In this context, Electrification and efficiency can be considered the key drivers of the energy transition, enabled by renewables, hydrogen, and sustainable biomass.

EMISSIONS REDUCTION 2018-2030



2. THE TRANSITION TO RENEWABLE ENERGY

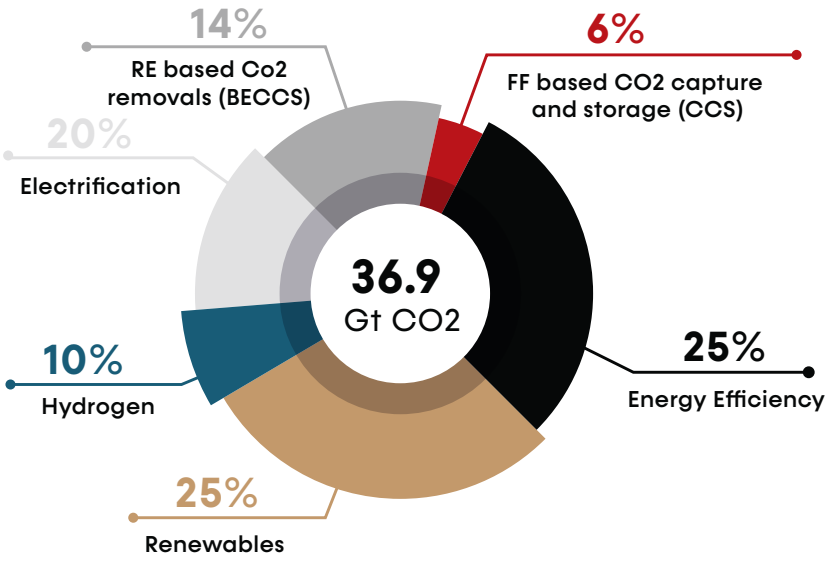
Ramping up renewables, together with an aggressive energy efficiency strategy, is the most realistic path towards halving emissions by 2030. With this regard, renewable energy share in electricity generation should increase to 65% by 2030. Direct renewables in end use sectors also should grow from 12% in 2019 to 19% by 2030.

As also shown, renewable energy and energy efficiency coupled with deep electrification of end-uses count to about 70% in the reduction of energy-related co2 emissions by 2050.

The share of renewables in the energy mix has increased over the past years. In 2000 it was 6.6% and continued to increase to reach 11.2% in 2020. Yet fossil fuel is still dominating with the largest share.

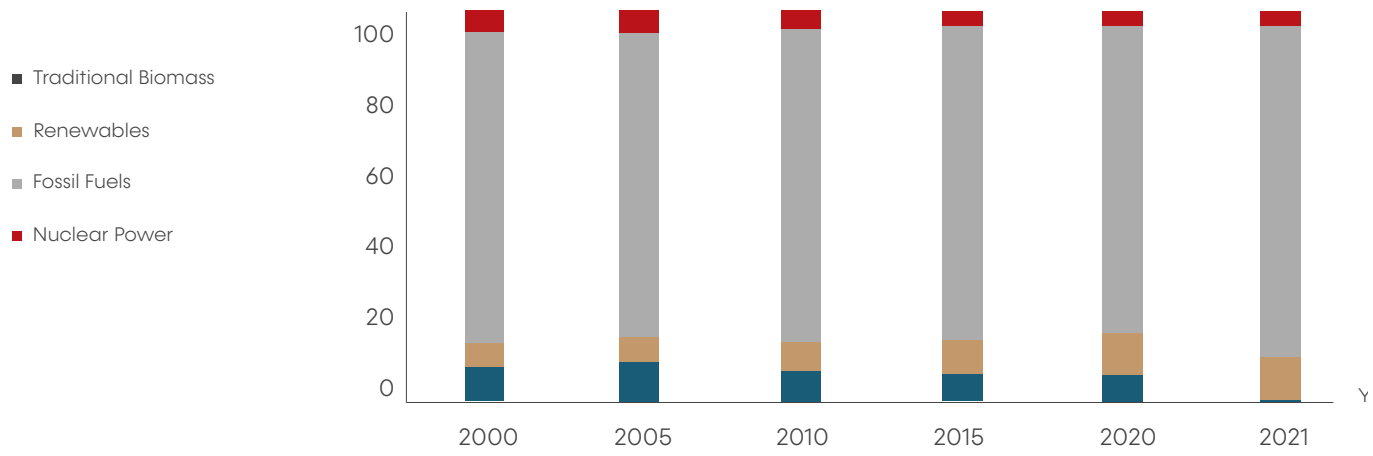
Renewable energies are the cornerstone of the energy transition. However renewable energy still needs to be scaled up at least six times faster for the world to start to meet the goals set out in the Paris Agreement.

REDUCING EMISSIONS BY 2050 THROUGH SIX TECHNOLOGICAL AVENUES



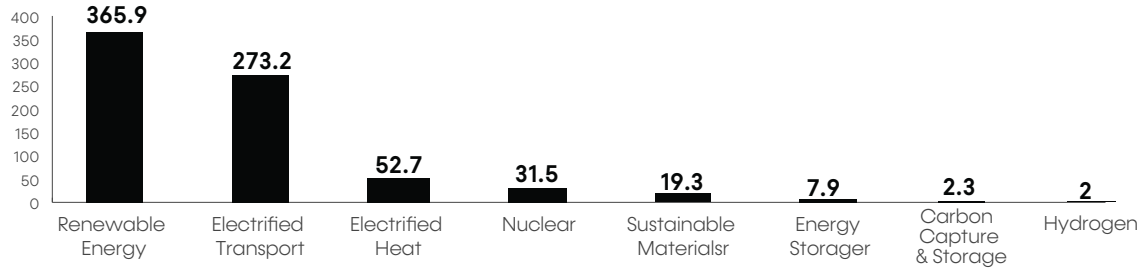
RENEWABLE ENERGY TRANSITION

SOURCES SHARES IN ENERGY MIX (%)

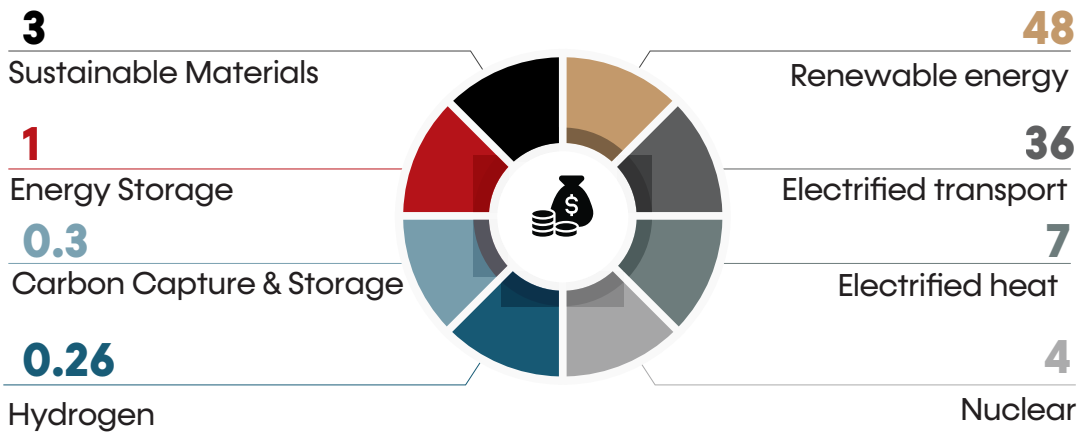


LOW-CARBON TECHNOLOGIES ATTRACTED MORE INVESTMENTS

TOTAL INVESTMENT IN 2021 ($ billion)

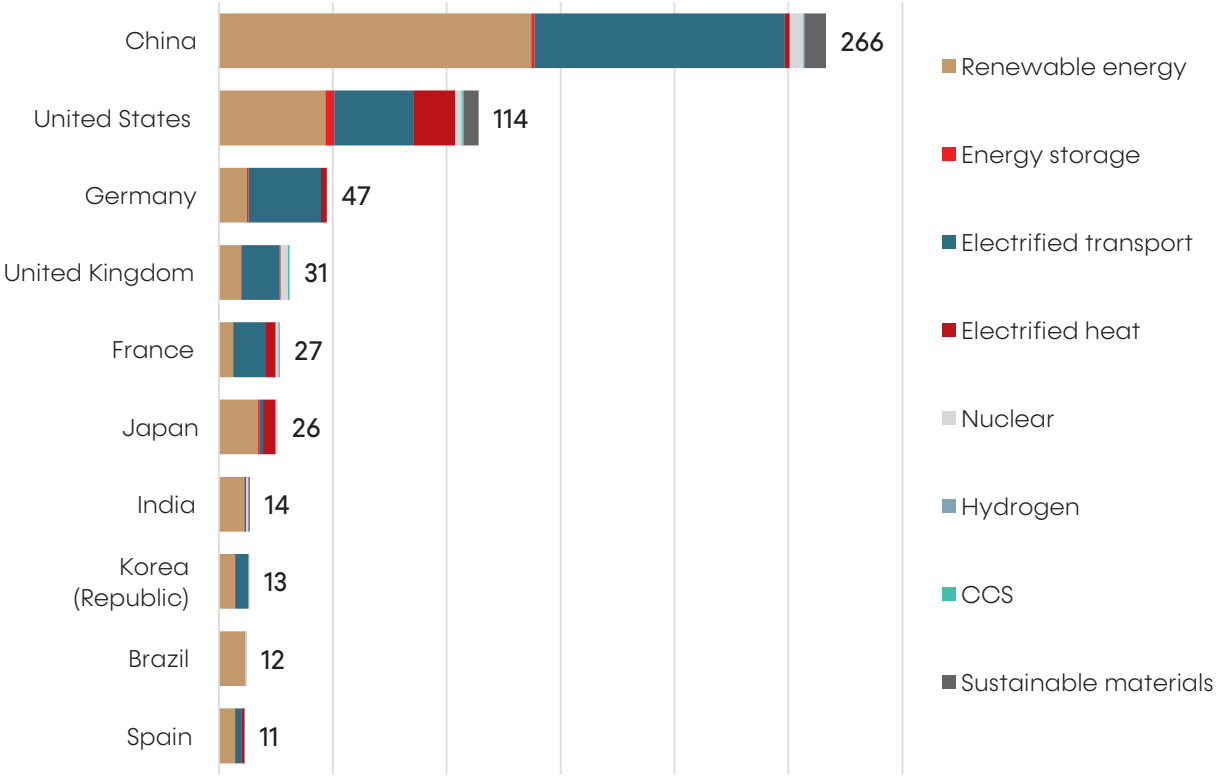


SHARE FROM TOTAL INVESTMENT (%)

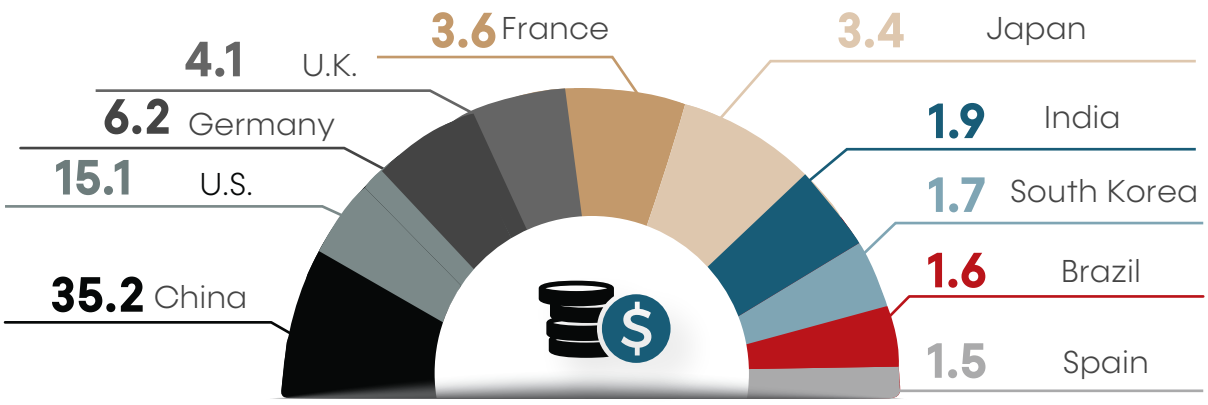


THE TOP 10 COUNTRIES BY ENERGY TRANSITION INVESTMENT IN 2021

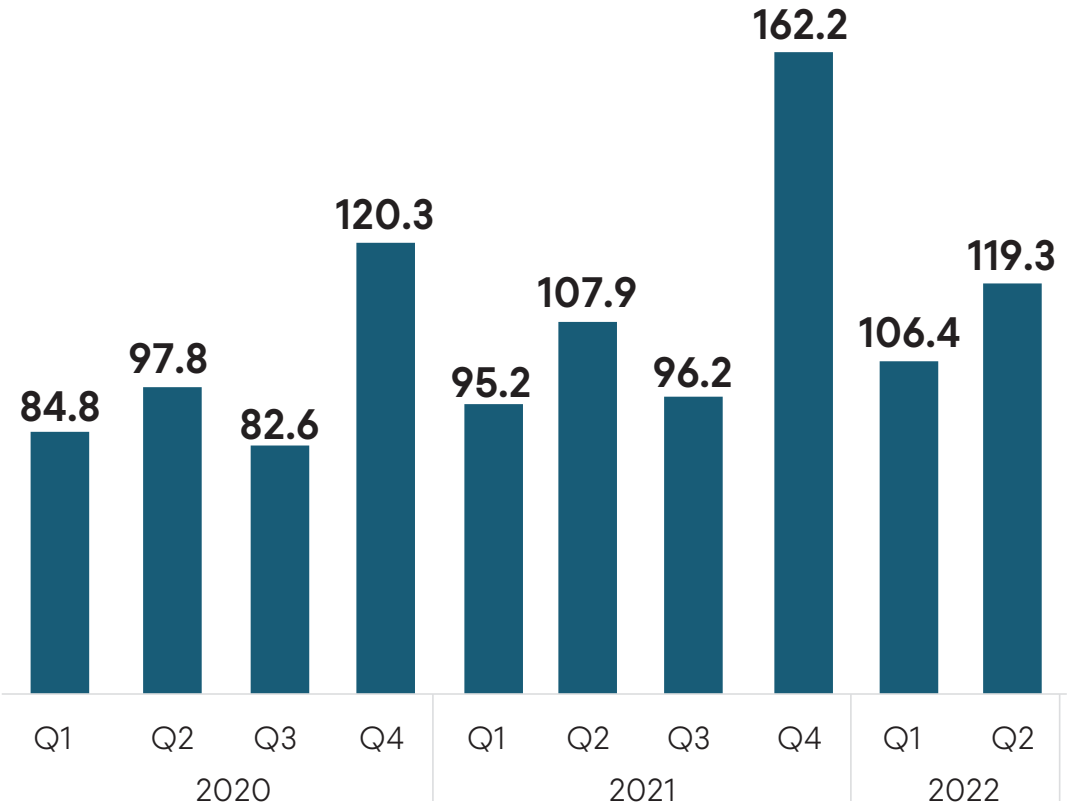
INVESTMENT BY COUNTRY ($ billion)



SHARE FROM WORLD'S TOTAL INVESTMENT (%)



GLOBAL NEW INVESTMENTS IN RENEWABLE ENERGY ($ billion)



Consequently, in 2021. Renewable energy came first in attracting investments in low-carbon technology, accounting for about $366 billion with a share of 49% and an annual increase of 6.8%. Renewables prices are competitive with the traditional sources of energy. New solar photovoltaic (PV) and wind energy plants are more profitable than fossil and nuclear plants around the world. Electrified transport came in second place with a share of 36%. Over one billion electric vehicles could be on the road by 2050 if the world starts soon on the path of decarbonization.

On the countries' level, China is the leading country for energy transition investments. The country spent $266 billion on investments in 2021, recording 35.2% of the global total investments. Renewable energy growth is greatly driven by a rush of investments in large- and small-scale solar projects. China has set two major carbon emissions targets, the first will be reached in 2030. As part of the decarbonization plan, China has announced several major renewable energy projects and investments.

The second biggest investing country is the U.S., as it spent $114 billion in 2021, recording 15.1% of the total world's investments. Countries in Europe exceeded $10 billion on energy transition investment last year.

ECONOMICS OF ENERGY TRANSITION

BOOSTS **GLOBAL GDP**

2.4%

2019-2050

USD **98** Trillion

CREATES **JOBS**

42 million citizens

Employed in renewables by 2050, **4X** more than today

IMPROVE **WELFARE**

capturing

More health, environmental and climate benefits

Saving

Up to 6x more than the additional costs of decarbonization

The world needs more investments in low-carbon technologies in 2050

3x investments — In renewable energy

+ $830 billion — In net incremental investments per year compared to current plans and policies.

3. ECONOMICS OF ENERGY TRANSITION

The global energy transformation makes economic sense. The additional costs of the comprehensive, long-term energy transition would amount to $1.7 trillion annually in 2050. However, cost-savings from reduced air pollution, better health and lower environmental damage would far outweigh these costs. The energy transition would significantly improve the energy system's global socio-economic footprint, global welfare, GDP and employment.

4. SCENARIOS

There are three main scenarios (Accelerated, Net Zero, and New Momentum) to explore the range of possible pathways for the global energy system to 2050 and help shape a resilient strategy.

The scenarios consider carbon emissions from energy production and use, most non-energy related industrial processes, and natural gas flaring plus methane emissions from the production, transmission and distribution of fossil fuels.

Accelerated and Net Zero explore how different elements of the energy system-as societal preferences and behaviour- might change in order to achieve a substantial reduction. New Momentum is designed to capture the broad trajectory along which the global energy system is currently progressing. It places weight both on the marked increase in global ambition for decarbonization seen in recent years and the likelihood that those aims and ambitions will be achieved, and on the manner and speed of progress seen over the recent past.

The Net Zero scenario expects that the share of fossil fuels in primary energy demand would decrease to 19% by 2050 from the current 83.15%. On the contrary, renewable energy demand would increase to 64% from 5.7%.

In the Accelerated Transition scenario, fossil fuels would represent 31% of primary energy demand by 2050. Energy demand would rise slightly by 2050; fossil fuels energy consumption would decrease, including natural gas consumption, which would decline after reaching its peak in 2035. Renewable energy consumption would rise dramatically, from the current level to 56% in 2050.

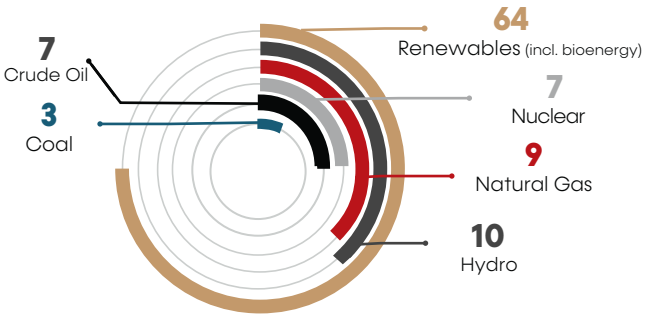
Under the New Momentum scenario, the energy demand would also rise slightly by 2050, and fossil fuels would represent 57% of primary energy demand. The share of renewables in energy demand could reach only 33% by 2050.

The three scenarios expect the increase of the dependence on renewable energy. However, these scenarios could be revised and reshaped after the Russian-Ukraine war and the need to accelerate the energy transition process.

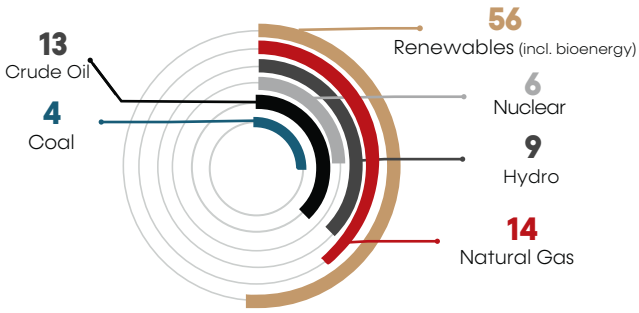
On countries' level, the emerging market has the highest share in primary energy demand with 75% while the remaining 25% is embraced by the developed countries. China and India are the biggest energy consuming countries by 22% and 13% respectively. In India, the share of non-fossil fuels (including nuclear energy) could rise to 76% of total consumption by 2050; while in China the share could rise to 67%.

SHARE OF PRIMARY ENERGY IN 2050 SCENARIOS

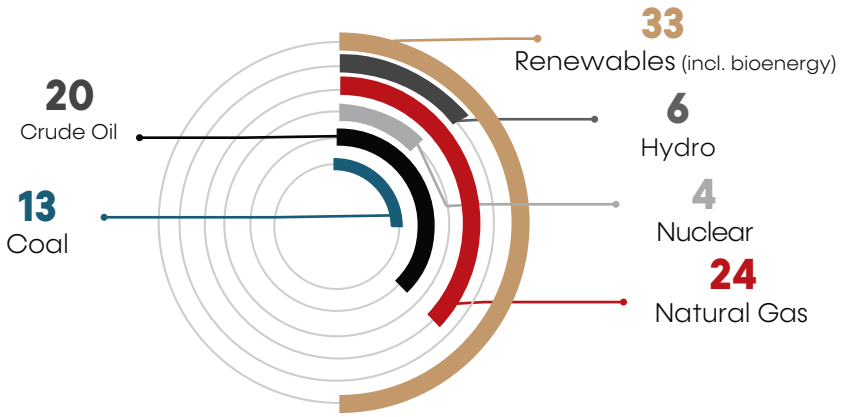
NET ZERO SCENARIO (%)



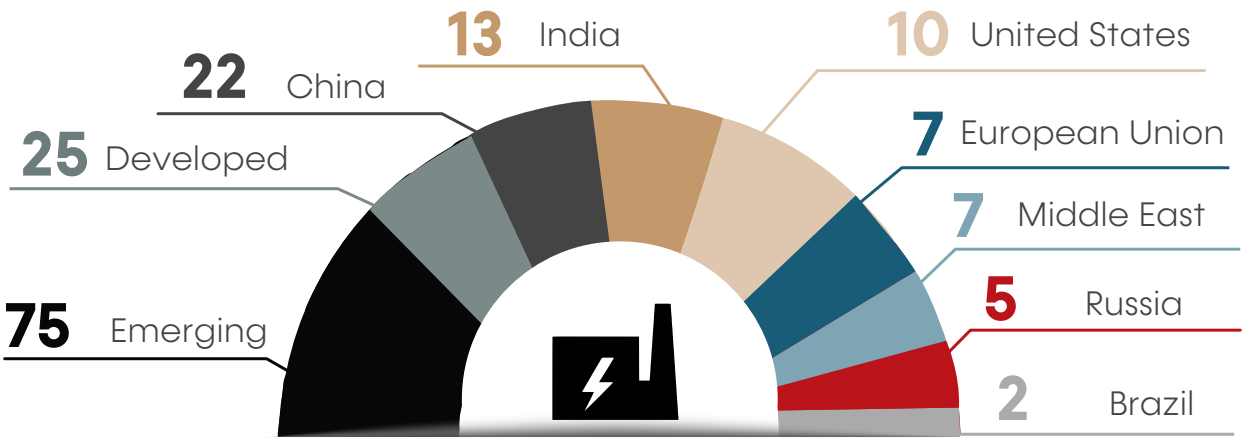
ACCELERATED SCENARIO (%)



NEW MOMENTUM (%)



PRIMARY ENERGY BY REGION IN 2050 (%)



TOMORROW'S ENERGY MIX

1. NEW BUSINESS MODEL

As the share of renewables in the energy mix increases, there would be a need to explore new business models for the future. These new models will have room for new products, services, and new ways of operating existing businesses. These include clean energy, alternative fuels, network management services, mobility services such as electric vehicle (EV) charging stations, energy-storage solutions, and energy platforms.

To accelerate the implementation of the new-energy models, organizations should step up their ability to innovate and become more open, creating new partnerships by investing in technology and talent and developing new ways to measure the success of new businesses.

After all, energy and utility organizations should recognize the need to position themselves towards meeting the demands of a decarbonizing world.

2. FOSSIL FUEL ROLE IN THE FUTURE ENERGY MIX

According to Copenhagen economics study, Fossil fuels will still provide 60% of energy in 2040, compared to 85% today, but the pattern of use will change, away from coal and towards gas, and increasingly concentrated in industry.

Fossil fuel prices would be lower in a 2˚C scenario, with less need to mobilize high-cost reserves to meet demand. However, additional investment in oil and gas will still be required. Even in a 2˚C scenario, the majority of hydrocarbon supply in 2040 would come from new developments.

It is claimed that the developed world has built its existing economies on fossil fuels and is still heavily dependent on them. Rather than a "non-fossil" only agenda, a more pragmatic approach that encourages all to use the broad range of resources available to them (i.e. energy efficiency, renewables and fossil fuels in a sustainable manner) will create a more balanced approach.

ENERGY TRANSITION TRENDS

The energy transition has been talked about for many years – but now the COVID-19 pandemic has given the world an opportunity to make it happen more quickly through accelerating a series of trends that are already underway: namely decarbonization, decentralization, and digitalization.

1. DECARBONIZATION

With renewable energy reshaping the power sector, decarbonization is grabbing a bigger foothold among governments, utilities and companies eager to lower their carbon emissions.

The key to effecting this is electrification or gradually replacing technologies that use fossil fuels with technologies that use electricity only from renewable sources in all sectors.

Hydrogen is also widely seen as a solution to lower emission challenge, so we can see a wide range of government policy schemes is underway to support their move to hydrogen.

Successful decarbonization still rests on lowering emissions wherever and however we can. For emerging and developing markets, for example, LNG will also play an important role as an interim step toward full decarbonization.

2. DECENTRALIZATION

A key element in accelerating the energy transition is decentralization. This is a shift away from the traditional utility business model, in which monopolist power companies distribute their energy from large power plants to the end-user.

What replaces it is a distributed energy network with a democratic business model in which energy consumers manage their own energy portfolio. Such a set-up could include renewables, homes and factories, batteries, and fuel cells, to name a few.

In the centralized model, more power is generated and distributed when demand peaks. In a decentralized system, demand response is used to manage distribution and grid stability. The number of energy consumers, equipment, and demand patterns that must be orchestrated is enormous.

Several countries and energy companies have been experimenting with new market mechanisms to manage these challenges in a way that provides incentives for users – for example, Cornwall Local Energy Market or Vermont Green.

3. DIGITALIZATION

Digital infrastructure has the potential to drive positive social, economic, and environmental outcomes, playing a critical role in the transition to net zero and delivering the SDGs

Digitalization is paramount to the success of energy transition as it is already improving the safety, productivity, accessibility and sustainability of energy systems today. Over the coming decades, digital technologies are expected to make energy systems more connected, intelligent, efficient, reliable and sustainable.

A high degree of sophisticated automation and analytics is needed to manage a system powered by an increasing variety of energy sources.

Supporting technologies such as predictive AI, machine learning, IoT, and blockchain are critical in the energy transition, hence comes the role of . innovative companies that approach digitalization strategically, while balancing the short and longer term objectives of the business.

The energy sector has been an early adopter of digital technologies. Oil and gas companies were pioneers in using digital technologies to improve decision making for exploration and production assets, including reservoirs and pipelines.

And today we can easily notice the increasing pace of digitalization

in energy. Investment in digital technologies by energy companies has risen sharply over the last few years. According to an IEA report, global investment in digital electricity infrastructure and software has grown by over 20% annually since 2014, reaching USD 47 billion in 2016. This digital investment in 2016 was almost 40% higher than investment in gas-fired power generation worldwide (USD 34 billion).

Digitalization will be critical for operational and commercial success. It will become central for several energy aspects including, energy management, energy mix optimization, Smart grids, Smart building and installations, Smart metering, Smart energy storage, Transactions and cybersecurity among others.

Digitalization can also be the answer for the key challenge of intermittent renewable power in energy transition as digital infrastructure can help integrate renewable energy sources into the power mix and improve reliability of supply.

By all means, digital infrastructure is critical to achieve net-zero targets by 2050. Digital infrastructure assets and technologies can reduce the GHG-intensity of electricity grids and drive efficiency in the real economy, enabling circular and service-based business models which use less resources, and embedding transparency into supply chains to support a nature-positive economy.

Energy transition is our way for not only creating a net-zero future, but also a more sustainable, cleaner and more efficient future energy mix. It's one goal that many paths can lead to. However, contributions and innovations from companies of energy, industries and IT will be critical to achieve this goal.

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