CIO Office Insights

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ALJAZIRA CAPITAL الجزيرة للأسواق المالية

Introducing Nuclear Energy

September 2025

KEY TAKEAWAYS

In 2024, global energy demand increased by 2.2%, with fossil fuels still accounting for over 80% of the energy mix. This underscores the ongoing challenge of transitioning to cleaner energy sources.

Renewable energy sources, like solar and wind, although are essential but are not the solution to the challenges faced in meeting the growing energy demand while reducing the carbon footprint.

Nuclear power provides a stable energy supply, complementing intermittent renewables like solar and wind, and is essential for meeting energy demands and combating climate change.

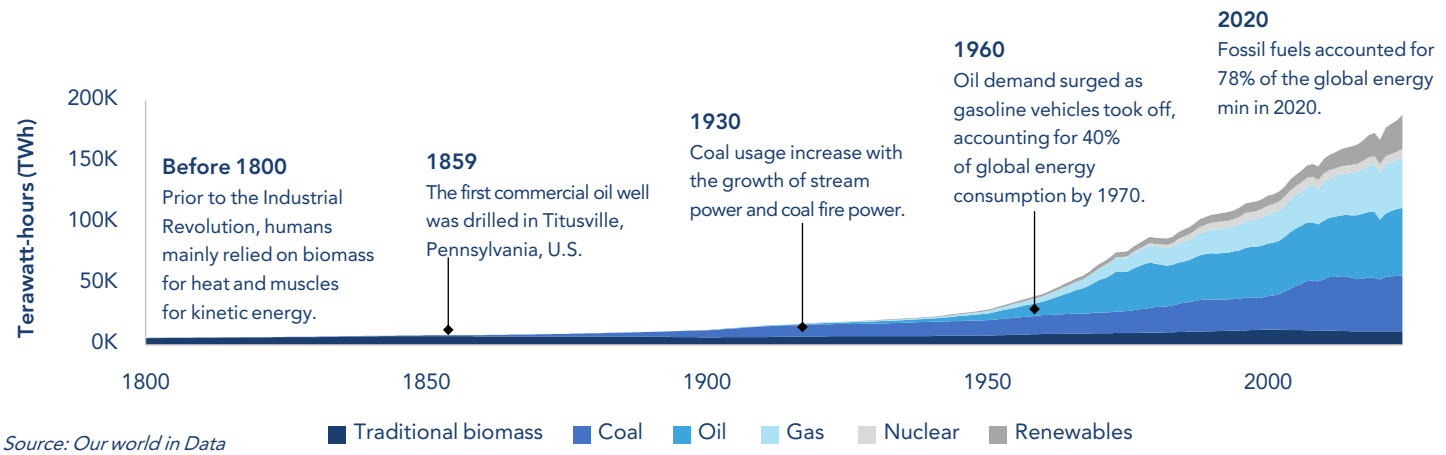
Innovations like small modular reactors (SMRs) and advanced fuels development like HALEU are expected to improve efficiency, sustainability and safety of nuclear energy.

In an era marked by rapid population growth, increased need for a secure energy mix and the critical need to combat global warming, the quest for sustainable energy sources has become more pressing than ever. Among the various contenders for our energy future, nuclear power stands out as a potent solution.

DEMAND FOR ENERGY

Energy has always been and remains central to human achievement and progress. The world's demand for energy has surged over the past century due to factors such as rapid urbanization, industrialization, and significant technological advancements, alongside the substantial growth in global population.

The world population is increasing rapidly and is expected to reach 9.7 billion by 2050[1]. The International Energy Agency (IEA) Electricity Market report 2023 predicts Asia will account for half of global electricity consumption by 2025, with China accounting for one-third. Global demand is expected to grow by 3% annually.



Source: Our world in Data

The increasing use of **technology**, including computers, smartphones, AI, and IoT devices, has led to a rise in data centers, which consume a significant portion of the world's energy, resulting in a surge in electricity demand.

The IEA estimates that global data center electricity use in 2024 was about 1.5% of total global electricity demand (around 415 TWh), and this consumption is projected to more than double to 945 TWh by 2030.

The growing concern over the climate impact of energy sources is accelerating global demand for clean energy. In 2024, Earth experienced its warmest year on record, with average temperatures exceeding 1.5°C above pre-industrial levels for the first time, highlighting the urgent need for a rapid shift to low-carbon energy sources[3].

1. UN.org
2. EI states, 2024.
3. WMO, 2025

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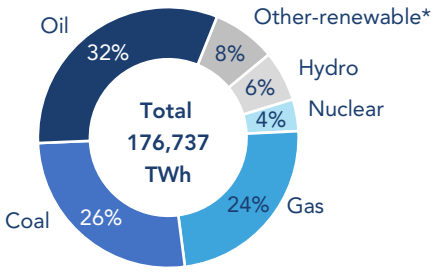
THE ENERGY MIX

In 2024, energy demand increased by about 2.2%. Fossil fuels (coal, oil, gas) accounted for ~81.9% of total global energy mix, down from 82.8% in 2023[1]:

- **Total primary energy** consumption rose by ~2.6% over 2023.
- **Renewable sources** accounted for 14% of the total primary energy consumption. Together with nuclear, they represented over 18% of total primary energy consumption.
- **Fossil fuel** consumption dropped by 0.9% to 81.9% in 2024. Projections indicate that this trend of decarbonizing energy sources will continue, driven by ongoing efforts to reduce carbon emissions and enhance energy efficiency.

The Primary Energy consumption, 2024[2]



CLEAN ENERGY

The world faces a dual challenge: reducing harmful greenhouse gas emissions while meeting rapidly growing energy demands. While it could be difficult to cover all the demand with renewables alone, increasing the share of clean energy would help to cut CO2 emissions and meet a sizable amount of the world's growing energy needs.

Hydropower is the largest renewable energy source, accounting for about 14% of global electricity. It is expected to remain the leading renewable source until the 2030s.

Biomass is contributing about 2% of global electricity supply. It is extensively used for heating, electricity, and transport fuels, particularly in developing countries.

Nuclear power accounts for around 10% of global electricity, with over 440 reactors in operation across 32 countries.

Solar and wind power are now cost-effective and competitive with fossil fuels, making them crucial for a sustainable energy future. In 2023, their capacity grew by 67%, contributing around 17% to global electricity production.

Other renewables accounts for around 2.6% of global electricity production.

In 2024, nearly 41% of electricity is being generated from low-carbon sources[2].

Expanding Nuclear Programs: About 30 countries are either planning or initiating nuclear power programs, reflecting the growing recognition of nuclear energy's role in a balanced energy mix.

Unlike intermittent renewables like solar and wind, which depend on weather conditions, nuclear power plants offer a continuous and predictable source of electricity. This reliability is crucial for balancing the variability of renewable sources and ensuring overall energy stability while supporting efforts to combat climate change.

The GCC region aims to boost renewable energy in their energy mix, with UAE aiming for 44% of electricity generation by 2050 and Saudi Arabia aiming for 50% by 2030.

Renewable Limitation

Intermittency and Reliability

Solar and wind energy have relatively low energy densities, requiring large land areas to produce significant amounts of energy.

Resource Availability

The availability of renewable resources like sunlight, wind and rain can vary geographically, limiting their feasibility in certain areas.

Baseload Limitations

Energy storage technologies like batteries and pumped hydro storage are improving but still face limitations in capacity, efficiency, and cost to maintain a stable baseload power supply.

1. EI states, 2024.
2. Our World in Data

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NUCLEAR ENERGY

Nuclear energy is a form of energy released from the nucleus. This source of energy can be produced in two ways: fission and fusion.

Nuclear Fission	Nuclear Fusion
Process where the nucleus (the center) of an atom split into two or more smaller nuclei	Joining of two light atomic nuclei into heavier atom. This is the same process that powers the sun
Fueled by uranium, which has limited but sufficient supply	Fueled by Hydrogen isotopes, which are abundant and easily extractable
Releases 1 million times more energy than other sources[1]	Energy release is 3-4 times greater than fission
Proven track record in industrial operation	Still in experimental stage, not yet available for commercial deployment

Nuclear energy, with its combination of mature fission technology and the future potential of fusion, offers a crucial solution to meeting increasing energy demands and achieving significant emissions reductions as part of a diversified and resilient energy portfolio.

NUCLEAR FUEL CYCLE[1]

Nuclear fuel, Uranium, is the most essential ingredient in generating nuclear energy and it undergoes through multiple stages, from extraction to enrichment, before it is used in a nuclear reactor to generate energy.

Mining and Milling	Refining	Conversion	Enrichment	Fuel Manufacturing	Generation
KAZATOMPROM	Cameco	orano	TENEX ROSATOM	TENEX ROSATOM	EDF
Cameco	ROSATOM	Cameco	ETC	energy	energy
Yellow Cake PLC		ROSATOM	urenco	Westinghouse	TerraPower
orano		CONVERDYN			

All of the world's fission nuclear reactors are powered by uranium. The world's power reactors, require ~67,500 tons of uranium each year.

The world's present measured resources of uranium (6.1 Mt), are enough to last for about 90 years. Further exploration and improvements in extraction technology are likely to at least double this estimate over time.

Uranium demand is expected to climb by 28% by 2030 and nearly double by 2040, as governments ramp up nuclear power capacity to meet zero-carbon targets.

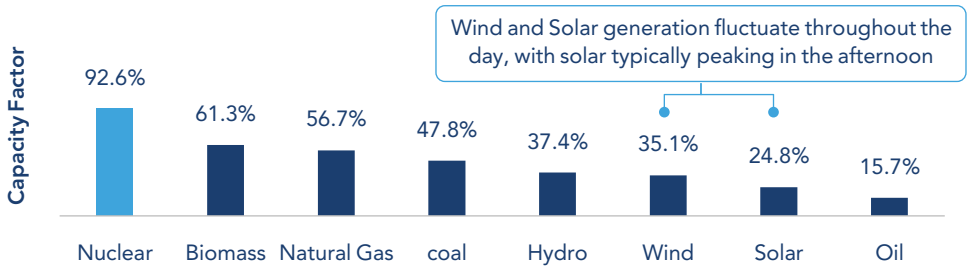
Innovations in reactor technology, such as small modular reactors (SMRs) and advanced fuel cycles like High-Assay Low-Enriched Uranium (HALEU), is expected to improve reactor efficiency and performance to support the continued expansion.

1. World Nuclear Association

NUCLEAR ENERGY MERITS

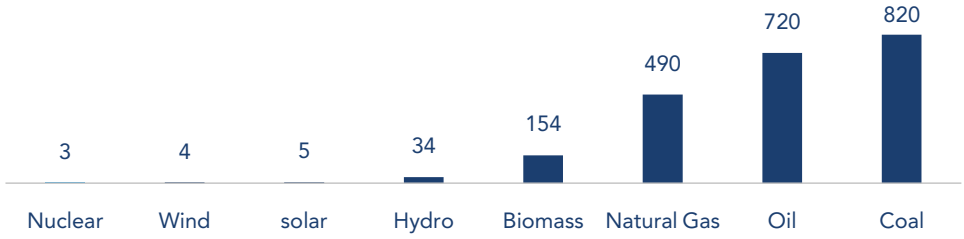
1. High Reliability

Nuclear plants provide a consistent electricity supply by operating continuously 24/7 for months, independent of weather conditions.



Source: U.S. Energy Information Administration and energy.gov.

CO_2 Equivalent Emissions per Gigawatt-Hour (MMTCDE)



Source: Our World in Data

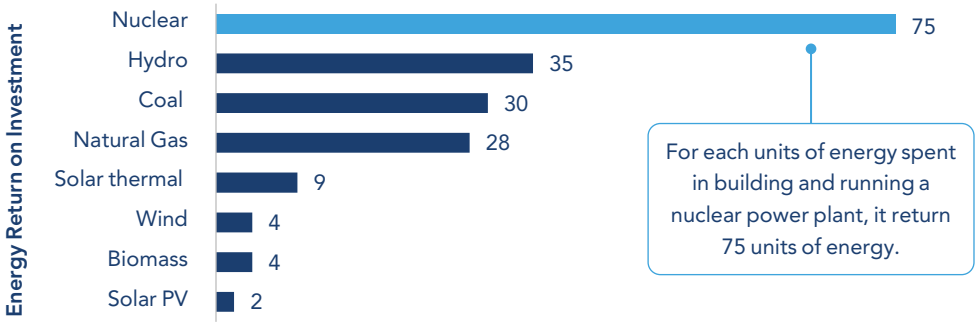
2. Clean

Among the main energy sources, nuclear energy has the lowest lifetime emissions during operation.

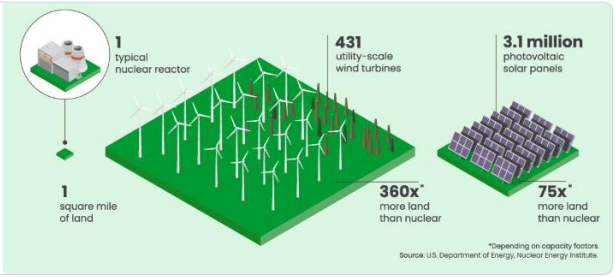
3. Energy Efficiency

Nuclear power is the most efficient source of energy, based on energy return on investment (EROI)*.

Furthermore, fuel costs only make up a small portion of operation costs for nuclear plants, offering stability in case of uranium prices fluctuations.



Generating 1 gigawatt of electricity takes



Source: U.S Department of Energy, Nuclear Energy Institute

4. Small Land Footprint

Nuclear power plants require less land compared to other renewables to power 100,000 homes for a year.*

5. Safe

Nuclear energy is safer than many other energy sources due to its rigorous safety regulations and low accident rates.

International Atomic Energy Agency (IAEA) leads the efforts globally to make nuclear energy safe.

Mortality Rate per TWh of Energy Produced

Energy Source	Mortality rate
Solar	0.02
Nuclear	0.03
Wind	0.04
Hydro	1.3
Natural Gas	2.8
Biomass	4.6
Oil	18.4
Coal	24.6

*EROI= Energy generated/ Energy spent to generate that energy
* Assuming the average home consume 10,000 Kwh of electricity .

NUCLEAR FISSION REACTORS & TECHNOLOGY

Nuclear reactors technology over the years have rapidly advanced, increasing there safety, efficiency and sustainability features. They can be broadly classified into three main types based on the reactor coolant. However, further distinctions can be made based on design, fuel, and operational aspects.

Water-cooled reactors

Pressurized Water Reactors (PWRs): They make up almost 70% of the global fleet, use high-pressure water as coolant and moderator to transfer heat and produce steam for electricity.

Boiling Water Reactors (BWRs): The water in the reactor core boils directly, producing steam that drives turbines to generate electricity.

Gas-cooled reactors (GCRs)

The gas transfers heat from the reactor core directly to the turbines for electricity generation.

Liquid Metal-cooled Reactors (LMRs)

These reactors offer excellent heat transfer properties and can operate at high temperatures, making them suitable for advanced reactor concepts.

With technological advancements, we are on the brink of deploying advanced reactors that promise to enhance efficiency and address the high capital costs challenges associated with traditional reactors.

300 – 1,000+ MW

Large- Scale Reactor

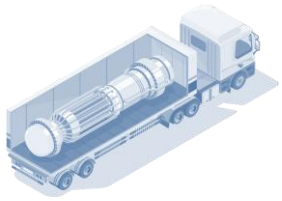
Currently used for reliable large-scale electricity generation. Large nuclear plants with advanced, proven designs and enhanced safety features are poised to play a crucial role in meeting future energy demands.

20 MW – 300 MW

Small Modular Reactors (SMRs)

Are advanced reactors that are much smaller than conventional reactors and can be transported and assembled in different locations.

1 MW – 20 MW



Microreactors (MMRs)

Are smaller than SMRs and are designed to provide electricity in remote and small market areas or as backup power source during emergencies.

Advantages of advanced reactor designs

- **Lower initial capital costs**
- **Portability and site flexibility**
- **Less Frequent Refueling**
- **Increased scalability**

As we face increasing energy demands and the challenges of climate change, nuclear energy will play an enhanced role in the energy mix. The emergence of advanced reactors and innovative fuels, such as SMRs and HALEU, is poised to transform the industry, playing a crucial role in achieving a low-carbon future.

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