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Opinion

Climate Change and Energy: The Role of Replacing Fossil Fuels in Achieving a Sustainable Future

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Opinion

One of the important parameters to measure economic growth of a nation has been traditionally considered to be per capita consumption of energy. In recent years the demand of energy has increased rapidly, because of extensive electrification and recent high demand from artificial intelligence (AI) data centres. Shipping and defence industries also contribute significantly to energy requirement. The burning of fossil fuels is the main source of energy and it accounts for about 80% of total world energy. This source of energy is an important factor for climate change, which is a long-term change in Earth's temperatures and weather patterns, mainly contributed by anthropogenic activities. These changes are generally attributed to burning fossil fuels (coal, petroleum, natural gas) for electricity generation, transportation, industrial production and domestic activities. The burning of fossil fuels release greenhouse gases, like carbon dioxide, methane and nitrous oxide. These gases trap terrestrial heat radiated from the earth's surface to increase its temperature. This leads to global warming, which is associated with widespread impacts like sea-level rise due to melting glaciers and extreme weather events (frequent and intense heatwaves, extended seasons, unusual floods, famines and storms).

In addition to climate change, which is the major drawback of fossil fuels, sources of these fuels are distributed highly asymmetrically across the globe and concentrated in few regions, creating high energy insecurity. The need of energy security is severely felt globally because of ongoing geo-political conditions, and dependence on a few countries for gas and oil. The entire world economy is being severely affected, because of extreme shortage of fuels.

Climate Change and Reduction of Greenhouse Gases

The relationship between energy and climate change is well understood, and accordingly adequate attention is being paid. The most important long-term response to energy-related climate change is to reduce greenhouse gas emissions at their source. Addressing this challenge requires a fundamental transformation of the global energy system with replacement of fossil fuels with low-carbon energy and non-polluting sources of energy, while ensuring that energy remains affordable, reliable and accessible.

Replacing Fossil Fuels with Low-Carbon Energy

Replacing fossil fuels with renewable energy sources (including solar power, wind energy, hydropower, geothermal energy, tidal energy), nuclear and hydrogen energy can significantly

reduce greenhouse gas emissions. These can reduce or reverse the impacts of climate change. Although reducing emissions is essential to limiting future warming, reversing some existing impacts will require sustained reductions in net greenhouse gas emissions and ultimately, net-zero CO_2 emissions. Energy efficiency, electrification, improved industrial processes and the development of low-carbon fuels can further accelerate this transition.

Renewable Energy

Replacing fossil fuels with renewable energy will lead to low carbon emissions with production of little to no greenhouse gases, helping combat global warming and climate change. These sources of energy provide cleaner air and water with much reduced atmospheric pollutants. These have operational costs significantly lower than traditional power plants. Thus, these provide enhanced energy independence by producing power locally and reducing reliance on imported fuels and volatile international energy markets. Some of these sources provide grid resilience and decentralization by modular and distributed energy systems (such as rooftop solar and microgrids).

However, these renewable energy sources have some core disadvantages in heavy dependence on time, weather and location. Their intermittency and weather dependence (for example, solar panels generate power when the sun shines, and wind turbines rely on active wind speeds) require expensive and limited energy storage. Generating high volumes of energy via solar and wind farms requires significantly large land and space. Thus, scaling up becomes difficult. These require heavy investment in energy storage and grid modernization.

Hydrogen Energy

Hydrogen energy is a clean, sustainable secondary energy carrier produced via water electrolysis, fossil fuels, biomass, etc. It uses hydrogen gas as a clean secondary energy carrier to store, move and deliver energy generated from other sources. Advanced technologies are being developed and employed for production, storage, transport, release and safety for various applications of hydrogen in transportation, heavy industry and stationary power to provide backup power and grid storage. Hydrogen is a fuel that, when consumed in a fuel cell, produces only water. Hydrogen can be produced from a variety of domestic resources. Green Hydrogen is produced via water electrolysis powered by renewable sources (like solar or wind) or nuclear energy, emitting zero greenhouse gases. Emerging low-cost and efficient catalysts are being developed to allow direct splitting of water. However, higher cost of hydrogen energy and safety, compared to traditional fossil fuels, are major concerns.

Nuclear Energy

Nuclear power produces baseload electricity with virtually zero carbon emissions. It is non-polluting i.e. helping decarbonization, easier scaling up, low-carbon energy with reliable and continuous power supply and caters to the energy security. At various fora of the United Nations (UN), International Atomic Energy Agency (IAEA), energy conferences, etc. nuclear energy has been suggested as an appropriate substitute to fossil fuels. Recent Global Energy Conference in India and the second nuclear energy summit at Paris in 2026 also highlighted importance of expansion of energy sources, strategic independence from fossil fuel import and use, and importance of decarbonization of energy.

It is understood that only nuclear can provide the required global security with clean and sustainable energy. Nuclear energy is gaining acceptability also because of its other important applications in agriculture, healthcare, industry and pollution control. Even the World Bank recognizes nuclear power's potential role in global clean energy transition. However, it supplies only about 10% of the world's electricity. Therefore, there is worldwide expansion of nuclear energy with maximum in Asia, which accounts for 80-85% of all reactors under construction.

However, the use of nuclear energy as a substitute to fossil fuels has problems in setting up a plant, which is highly expensive and technically challenging. Some countries are developing a small modular reactor (SMR) to address this problem. A SMR can be deployed rapidly with enhanced safety features, low investment and small footprint. It will be flexible for use of heat for an industry, hydrogen production and desalination. It can also be used for onsite power for energy facilities, e.g. AI data centres, shipping industries, defence, remote communities, etc. A SMR is an advanced nuclear technology with capacity up to 300MWe of electrical energy and operating with a capacity factor more than 90%. SMRs of smaller capacities are also being developed, such as Micro Modular Reactor (MMR) of up to 40-50MWe capacity and Portable Micro Reactors (still smaller capacity as 1MWe).

SMRs are still at developmental stage with no onshore commercial plant. Russia has world's first floating nuclear power plant with capacity of 35MW electrical energy, and now planning a SMR with similar technology for onshore use. Another solution to the conventional nuclear reactors is long-cherished development of a fusion nuclear reactor. The successful deployment of fusion, whenever possible, could be a game changer for global energy security, environment and economy.

Role of Other Agencies

A few decades back, processes of climate change were considered non-existent, and remained in the research domain of only environmental scientists and technologists. These scientists and some organizations, like the Intergovernmental Panel on Climate Change (IPCC), UN sponsored climate conferences (COP), have emphasized the importance of the climate change. It was observed that environmental and climatic conditions are very soon going to be quite alarming.

These scientists/engineers and global organizations started actively participating to improve and arrest the climate change, mainly by replacing fossil fuels with a clean energy source. The COP Conferences agreed on climate change, with long-term goals. All nations promised to substantially reduce global greenhouse gas emissions to contain increase in global temperature to below 2 °C with continued and sincere efforts to limit it to 1.5 °C.

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The IAEA opined that nuclear energy can provide clean energy source replacing fossil fuels to ameliorate global climate change, and in return it can get global support as a source of clean energy. The (COP28) meeting in 2023 at Dubai was a turning point for nuclear energy. It underscored accelerated deployment of nuclear technologies to mitigate the climate change. It was declared to triple global nuclear generating capacity by 2050. The recent COP30 in 2025 in Brazil declared to stay within the limit of 1.5 °C of global heating, agree for reducing fossil fuel usage, and offer appropriate support to developing countries.

Encouraging Developments on Clean Energy Source

A major hurdle in development of a clean energy source is financial constraint. Now, World Bank and Asian Development Bank are ready to finance nuclear projects. The IAEA and World Bank have agreed to cooperate on development and financing of nuclear power for developing countries. Other tech-giants (like Amazon, Google, Trump Media & Technology Group) are supporting growth of clean energy sources.

Introduction of artificial intelligence and other advanced technology is going to be very useful for construction, deployment, operation and safety of a nuclear power plant, and other renewable sources. It can reduce the installation time of new projects, and make them more efficient and reliable.

It is important to distinguish climate change from conventional air pollution. Many air pollutants have immediate local or regional effects, whereas carbon dioxide contributes to long-term global warming. Nevertheless, both problems can be addressed partly by reducing fossil fuel combustion and consumption of other highly polluting chemicals. Systematic experiments and computations are being performed world over to assess their harmful effects and thereby minimize their release into atmosphere. In addition to replacement of fossil fuels, sincere efforts are being carried out to develop technologies for efficient and economically viable carbon dioxide capture and sequestration from industrial facilities or power plants before they reach the atmosphere and permanently store them underground.

The Way Forward

Nuclear energy has been realized to be almost indispensable for energy security, climate neutrality and economy. However, no single energy source is appropriate for every location. The best strategy depends on local resources, costs, infrastructure, environmental impacts and energy requirement. Thus, the most effective environmental strategy and the best working solution involve often a holistic energy portfolio that combines renewable energy and nuclear energy rather than relying on a single source.

Although clean and sustainable energy sources are being developed, still capping the earth temperature rise of 1.5 degree is predicted to be challenging. Therefore, still more efforts are required to replace the fossil fuels to meet the net-zero energy and to contain the temperature rise. Sincere efforts have been initiated worldwide, and the projected target should be achieved in future.

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