ENERGY TRANSITION: TECHNOLOGICAL DIMENSIONS OF THE ZERO-CARBON PATHWAY

Muhammad Asif, King Fahd University of Petroleum and Minerals Dhahran, KSA
Email: asifm@kfupm.edu.sa, Mob: 00966540649188

Overview

The human use of energy has evolved through the course of history. Availability of refined and efficient energy resources has played a decisive role in the advancement of societies, especially since the industrial revolution of the eighteenth century. In the twenty first century, the international energy scenario is experiencing a profound transition as the world is experiencing a major shift in terms of energy resources and their utilisation. In recorded history, there have been two major energy transitions. The first one was a shift from wood and biomass to coal during the 18th century industrial revolution, and the second one was the 20th century transition from coal to oil and gas. The 21st century energy transition is manifested as sustainable energy transition or zero-carbon energy transition. This work examines the major dimensions of the zero carbon pathways for the unfolding energy transition taking into account key policy drivers and trends, technologies, challenges, and prospects.

Methods

The work explores the international energy and environmental scenario to determine the important technological and policy dimensions of the ongoing energy transition. It examines the frameworks, directives and outlooks of relevant national and international bodies and policy institutions, utilities, industry, academia, research and development (R&D) organizations, and development sector. A survey has also been conducted to determine the perspective of key stakeholders - i.e. policy and decision making circles, utilities, industry, academia, research and development (R&D) institutes, financial institutes, developmental sector and civil society - on the dynamics of the energy transition.

Results

The main findings of the work are as below.

- The key drivers of the ongoing energy transition include: climate change, energy insecurity, rising energy prices, and depleting fossil fuel energy reserves.
- The technological dimensions of energy transition can be classified under four broader categories: decarbonisation, decreased use (energy efficiency), decentralisation/distributed generation, and digitalisation
- Major challenges to a successful energy transition include lack of conducive policies, technological and investment constraints, and geopolitical disputes
- The energy transition requires dynamic and interwoven technology-policy partnership
- Localized socio-economic inequalities around energy insecurity are also a global concern
- The planet, a global village, has a shared future, for the developed and the developing nations.

Conclusions

The 21st century energy transition is much more vibrant and multidimensional as compared to the 19th and 20th century energy transitions thanks to the enormous changes and advancements on the fronts of energy resources and their consumption, technological advancements, socio-economic and political response, and evolving policy-landscape. This energy transition is driven by the global pursuit for sustainable development having energy and environmental sustainability at its heart. In terms of technology, the present energy transition has four broader dimensions: decarbonisation, decreased use, decentralisation, and digitalisation. Decarbonisation of the energy sector is led by solutions like renewable and low-carbon technologies, electric mobility, carbon capture and storage, and hydrogen and fuel cells. Decreased use of energy through energy conservation and management (ECM) is critical to energy sustainability. ECM is a widely established and techno-economically viable strategy across all major energy consuming sectors. Distributed generation or decentralised energy systems are becoming popular around the world to help cost effective and efficient supplies of energy. Digitalisation of energy systems is also deemed to be an important

aspect of future energy systems. The International Energy Agency (IEA), regards energy digitalisation as important to help improve productivity, accessibility, cost-effectiveness, and overall sustainability of future energy systems.

References

1. M. Asif, The 4Ds of Energy Transition: Decarbonization, Decreasing use, Decentralization, and Digitalization, Wiley, ISBN: 978-3-527-34882-4, 2022
2. M. Asif, Handbook of Energy and Environmental Security, Elsevier, ISBN: 9780128240847, 2022