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# Role of Energy Conservation and Management in the 4D Sustainable Energy Transition

**Muhammad Asif**

Department of Architectural Engineering, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia; dr.m.asif@gmail.com

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**Abstract:** In the twenty first century, the world is witnessing an unprecedented energy transition. This sustainability-driven transition, also termed the sustainable energy transition or low carbon transition, has four major dimensions: decarbonisation, decreased use, decentralisation, and digitalisation. Decarbonisation and decreased use of energy are already well established dimensions of the sustainable energy transition. Decreased use of energy through energy conservation and management (ECM) offers wide ranging benefits across all energy consuming sectors, i.e., buildings, industry, and transportation. The building sector, accounting for almost 40% of the world's total energy consumption, is particularly conducive to ECM. Estimates suggest that with the reliable and commercially available solutions, energy demand in both new and existing buildings can be reduced by 30 to 80%.

**Keywords:** energy; environment; sustainability; 4D sustainable energy transition; buildings; energy conservation and management; low-carbon transition; retrofitting

## 1. Introduction

Energy is a vital commodity that goes through a wide range of flows and transformations that are pivotal for the existence of human life on the planet. Increasingly extensive and efficient utilisation of energy has played a critical role in the evolution of societies, especially in the post-industrial-revolution era. Energy has become a prerequisite for almost all facets of life, i.e., agriculture, industry, mobility, education, health, and trade and commerce. The global demand for energy is experiencing a rapid growth. According to the Energy Information Administration (EIA), the world energy requirements are projected to increase by 50% by 2050 [1]. Further to the fast growth in energy demand, the international energy scenario also faces challenges like depletion of fossil fuel reserves, lack of access to refined energy resources, volatile energy prices, increasing greenhouse gas (GHG) emissions, and energy insecurity issues. In the modern age, energy is closely linked to the environment. The world also faces stringent climate change challenges including seasonal disorder, rising sea-level, a trend of more frequent and intense weather-driven disasters such as flooding, droughts, heat-waves, wildfires, storms, and associated financial losses [2]. The ongoing pandemic, COVID-19, has added another critical dimension to the catalogue of challenges facing the energy scenario. The energy sector is feeling the impact of the pandemic on multiple fronts. Oil prices have plunged due to the diminished demand with the United States having recorded negative prices in April 2020. The energy sector is also experiencing supply cuts, disrupted trade flows, mounting debts, and bankruptcies. The full and long-term impact of the pandemic is hard to predict. The set of the wide ranging challenges faced by the international energy landscape underpin the importance of sustainable energy solutions.

## 2. The 4D Sustainable Energy Transition

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 present energy transition is, however, much more vibrant and multidimensional as compared to the earlier ones 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–also manifested as sustainable energy transition or low-carbon energy transition–is driven by the global pursuit for sustainable development having energy and environmental sustainability at its heart. The sustainable energy transition has four important 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 [3].

## 3. Energy Conservation and Management

Energy conservation and management is one of the most promising dimensions of the sustainable energy transition. In terms of application and benefits, ECM measures have a huge scope. ECM measures offer a wide range of benefits not only at the individual and societal levels, but also at international and global scales. By reducing energy consumption, ECM results in economic gain and offers a competitive edge to industrial and commercial activities. It is regarded as a better solution to address energy shortages than developing new energy projects, and thus helps national energy security. Additionally, considering the losses involved in the energy equation–encompassing stages like production, transformation, transmission and distribution, and end use–a unit of energy saved is more cost effective and beneficial than the produced one. Another important global contribution of ECM is reduction in environmental emissions as a result of curtailed energy use.

Buildings, accounting for 36% of the world's total energy use and around 40% of the greenhouse gas (GHG) emissions, play an important role in the global energy and environmental scenario [4–6]. A building consumes energy throughout its life cycle. The operational phase of a building is responsible for most of the energy consumption, accounting for up to 90% of the life cycle energy use [7]. Compared to other sectors such as transport, industry, and agriculture, the building sector has the greatest potential for reducing energy consumption and GHG emissions. With the commercially available and viable solutions, energy demand in existing as well as new buildings can be cut by 30% to 80% [8,9]. Energy conservation is an integral part of the energy policies and developmental frameworks around the world. The European Union's 20-20-20 directive is an interesting example in this respect, which aimed to increase energy efficiency by 20%, reduce $CO_2$ emissions by 20%, and have renewables making up 20% of supplies by 2020 [10]. To bring a positive change in the building sector, ECM are required in new as well as existing buildings.

This special issue entitled 'Energy Conservation and Management in Buildings: Technologies, Policies, and Best Practices' signifies the importance of buildings and energy conservation and management towards the 4D sustainable energy transition. In this respect, the special issue includes seven chapters covering topics like energy efficient materials, estimation of $CO_2$ emissions from buildings, role of urban buildings in carbon emissions, energy saving measures in buildings,

application of PV systems in buildings, building performance simulation to design energy efficient homes, and housing energy efficiency certifications. In terms of geographic diversity, the special issue attracted contributions from countries across East Asia, Europe, Latin America, the Middle East, and South East Asia.

## 4. Conclusions

To tackle the faced energy and environmental challenges, the global energy scenario is envisioning a 4D sustainable energy transition. The four dimensions of this energy transition are decarbonisation, decreased use, decentralisation, and digitalisation. Decreased use of energy through energy conservation and management has to play a critical in this 4D sustainable energy transition. The building sector offers the greatest potential to save energy as compared to other sectors. Energy efficiency measures are required not only in the new buildings, but also in retrofit of existing building stock.

**Conflicts of Interest:** The authors declare no conflict of interest.

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