Global Energy: Challenges and solutions

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Abstract. The global growth of population and the rise of industrialization in developing nations led to rise the global energy demand that has attained highest level ever. The energy demand is projected to experience more increase in the coming decades, resulting in rising the carbon emissions and creating a global tension on the way of dealing with this growth. Renewable energy is one of the keys potentials to cope with the rise of the global energy demand. The current paper presents the current situation of the global energy sector, and the different challenges facing the integration of renewable energy in the energy system. Additionally, the paper highlights the different solutions that could facilitate the integration of renewable energy and enhance the benefits offered by renewable energy resources.

1 Introduction

The availability of energy has affected the evolution of mankind in the last few centuries. Different types of energy have been explored, starting with fossil fuels, followed by nuclear, hydropower, and recently renewable energy resources. Additionally, the quantity of produced and consumed energy experiences a high increase, positively affected the economy and the wellbeing but negatively affected the environment and causing global warming. More than 50 % of our energy are generated from fossil fuels, since commercial oil drilling began in the 1850s [1]. It is predicted that we have consumed more than 135 billion tonne of crudes oil to operate our power stations, heat and cool our homes, and drive our cars. Figure 1 displays the evolution of the global electricity demand between 1990 and 2025. It can be seen the high rise of the electricity demand, starting from 1990, mainly in Asia, Latin America and parts of Africa.

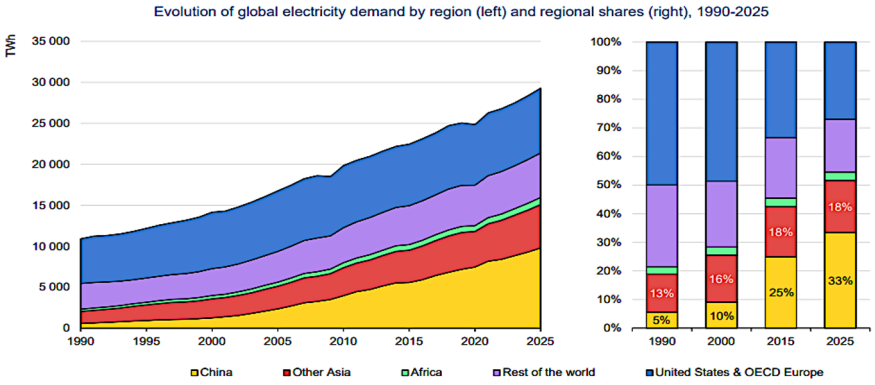

Figure 1 Evolution of the total electricity demand between 1990-2025 [2]

According to IEA, Asia will account around fifty percent of the globe's electricity consumption and China will account for one-third of the world's electricity consumption [2].

Currently, two major energy issues are facing the world and could be solved through scaling up the alternative energy resources. The first issue is having access to clean and renewable energy resources, and the second issue is how to deal with the expected rise of energy demand in the coming years. Actually, there are around three billion people across the globe who use stoves or open fires that burn wood or waste to cook and heat their houses. The global energy demand increases and is expected to increase more due to the industrialization of many developing countries, increasing wealth, and population growth. The global warming also rises the energy demand for cooling. According to the United Nations' Intergovernmental Panel on Climate Change, the energy demand for cooling will exceed the demand of heating by the middle of the current century due to the global warming [3]. It is predicted that the global energy consumption will have raised by 50% by 2040 [4]. This huge growth of energy demand will rise the

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greenhouse gas emissions if energy is generated by burning more fossil fuels.

A new low carbon energy plan is needed to deal with the surplus of energy demand and replacing the use of fossil fuels by cleaner energy resources. Renewable energy resources and decarbonizing the fossil fuels could play a crucial role in facing the rise of global energy demand without harming the environment. The decarbonization of fossil fuels is possible, but the fundamental technology is in incomplete stage of growth and is obscured by doubt and incertitude in terms of integration speed and the ultimate practicability of highly scalable application of carbon capture and storage. Additionally, the world is facing a big challenge of transitioning the global energy systems toward renewable energy resources with the rising of energy consumption. It is projected a rise in the total yearly investment in the energy sector by up to 4%/year till 2040, achieving US$ 2 trillion to US$ 3.2 trillion [4]. A rise in investment in the decarbonization technologies by 6 to 11%/year is projected, energized by strong consumption of EV charging infrastructure and carbon capture utilisation and storage (CCUS).

The current paper aims at presenting the current situation of the global energy sector, highlighting the main challenges facing the global energy demand. The paper shed the light on the potential of renewable energy in meeting the global energy challenges. The different challenges faced the integration of renewable energy in the global energy system and the solutions are also presented in this paper.

2 Share of renewable energy in the total energy

Currently, the renewable energy accounts around a fifth of the globe's primary energy supply, like solar, wind, and hydro, with a prediction of a growing by 2.6% yearly till 2040 [5]. Until now, wind energy and hydroelectricity are the main renewable energy resources that experience the rapidly growth. The energy generated using the sun has been increased owing to the new advancement of solar cells and panel technology, that enable them to produce energy in clouded conditions. The total primary energy supply will remain unchanged owing to the growth of energy efficiency and renewable energy resources. The need of renewable energy will grow over all end-use sectors. The electrification rate, that is experiencing a high rise in many sectors, mainly in buildings and transportation, will need a twelve-fold rise in renewable energy ability by 2050, in contrast to 2020 levels. Under the 1.5 °C scenario, there is a global need to around 1066 GW/year of renewable energy capacity additions from 2023 to 2050. In this scenario, electricity will be the primary energy carrier, accounting more than 50% of the overall final power consumption by 2050. The main contributors are the implementing of renewable energy, enhancing energy efficiency, and the end-user sectors electrification. Moreover, hydrogen and advanced biomass have the potential to meet 14% to 16% of the overall final energy consumption by 2050, successively [6]. Green hydrogen will account 94% of the generated hydrogen in the 1.5°C scenario, by 2050 [7]. Hydrogen has a significant potential in the decarbonization process of final uses and resilience of energy system.

Renewable energy could play a fundamental role in ensuring energy security, that is considered as the principal engine in the geopolitical environment. Nations with large oil reserves could predominately mandate international policy and nations such as the Kingdom of Saudi Arabia, the US and Russia. Thus, the development and the integration of renewable energy will change the geopolitics of energy

Renewable energy resources are expected to head the power generation, attaining 80-90%, in 2050 [8]. Solar and onshore wind are expected to account the highest growth percentage owing to reductions costs, and they are expected to account around 43% and 26% of production successively in 2050 under the Further Acceleration scenario [4]. However, offshore wind is expected to maintain bounded to less than 7% of the universal production because of authorizing constraints and policy obstacle, with a possibility to continue growing in case of persisting of constraint on onshore like land use.

3 Challenges facing the renewable energy

The renewable energy faces a considerable challenge related to its intermittency, that has economic, social, and environmental implications. For instance, the high generation of energy using the sun in summer while the demand is low, is an issue that cannot be easily solved, because storing energy in great amount is not possible. Actually, some countries are dealing with this issue by retaining more reliable power generation source as backup. This implies power stations fuelled by nuclear, gas and coal, preforming at low level or not working, but intended to boost their production when needed, in case of low wind speed, at night, or under cloudy conditions. Additionally, super-grids, that enable the grids to distribute the electricity in larger scale, could be a solution [9]. The principal idea is based on the fact that energy is sharing over a larger area, the sun shines or the wind blows in a part of the electricity supply network, but not in another part. These strategies visualise joining the energy grids of different nations collectively to share the electricity between countries. Transmitting electricity from a country with a less energy demand to country with high energy demand can achieve financial benefits and minimize the need to build new energy projects. However, this solution faces some challenges in terms of efficiency, since transporting electricity for long distance is inefficient and nations will require to promote their powerline to deal with [10]. On the other hand, a development of an efficient storage method will diminish the use of super grid.

Renewable energy resources are facing more challenges in terms of infrastructure, policies and regulation, and skills and institutions capacities [11-13].

- Infrastructure: A deficiency of infrastructure to link renewable energy to market, comprising energy

storage and grid connection infrastructure, is one of the challenges facing the integration of renewable energy. Additionally, there is an unpreparedness of final consumption facilities for renewable energy transition.

- Skills and institutions capacities: A mismatching between fossil fuel energy jobs and renewable energy job gains in terms of skills related, spatial, temporal, and sectoral presents a challenge for the incorporation of renewable energy. Skills shortages caused by inappropriate education and training opportunities, inequitable access for women and minorities, and insufficient knowledge on opportunities.
- Policies and regulations: the existing policies and regulations are crafted around fossil fuels, resulting in limited funding for energy transition. The absence of comprehensive planning for the generation and consumption of energy assistance negatively affects the integration of renewable energy resources. Also, insufficient interest to the socio-economic dimensions, comprising absence of industrial policy for feasible supply chains, is considered as a constraint for the vast deployment of renewable energy.

4 Solution for a successful integration of renewable energy

There are many solutions that could facilitate the integration of renewable energy resources and enhance the benefits from renewable energy.

- Making renewable energy technology a collective global benefit [14]: this means that renewable energy should be available to everyone, not only to the upper class. It is crucial to take away barriers to knowledge exchange and technology transfer, involving intellectual property rights obstacle. Some key technologies, like energy storage system, are crucial to enhance the benefits of renewable energy resources since generated energy by renewable resources could be stocked to be reused when needed. Thus, an enhancement of the flexibility of the energy systems could be achieved. For instance, battery storage technologies could offer dependable and affordable energy in off-grid system in remote and isolated locations.
- Enhance universal access to components and raw materials [15]: A reliable and resilient supply for the key elements and starting material used in the manufacturing of renewable energy technologies, such as solar panels, wind turbines, and electric vehicles, is fundamental. A considerable international cooperation is required to develop and diversify generation capacities universally. Additionally, bigger investments are required to assure the transition to renewable energy, involving research and development, vocational and kills training, and encouragement and reward to establish logistics chains by means of sustainable practices that preserve and save ecosystems and culture.
- Equalise and liberalise renewable energy technologies [16]: even though the universal collaboration and partnership is fundamental, national policies frames should promptly be repaired and reorganised to streamline and accelerate renewable energy projects and promote private investments. Policies and procedures are needed to minimize the market risk and assure and encourage investment to ensure the existence of technology, funds, and capabilities for renewable energy transition. These policies should include enhancing the planning, avoiding congestions and bureaucracy. Additionally, it can incorporate assigning space expansive buildouts in particular renewable energy areas. Hasting the benefits of solar and wind energy requires defined and robust policies, national support, clear operation and procedure, and availability of advanced energy transmission systems.
- Transfer energy subsidies from petroleum to renewable energy [17]: fossil fuel subsidies are considered as a significant fiscal impediment hindering the universal's transition to renewable energy. Fossil fuel subsidies are ineffective and unbalanced. Around fifty percent of public funds expended to boost fossil fuel consumption avails the wealthiest citizen with a percentage that reaches 20% in developing countries according to the International Monetary Fund. Transferring subsidies from fossil fuels to renewable energy leads to minimize the greenhouse emissions, and promote the development of sustainable economic, job creation, better healthcare and more fairness, mainly for the poor and aggrieved communities worldwide.
- Triple investments in renewable energy sectors: rising investment in renewable energy with no less than US$ 4 trillion per year, involving infrastructural and technological investments, is required to achieve the target of net zero emission by 2050. Additionally, the diminishment of population and carbon dioxide footprint could economize the globe up till US$ 4.2 trillion a year by 2030. Commitment and accountability for funding is crucial, mainly from the world economic system, comprising international financial institutions as well as public and private banking institutions, that should line up their loaning portfolios towards promoting renewable energy transitions.
- Storing the surplus of energy generated by renewable energy resources in the form of fuel [18]: hydrogen is considered as the fuel since it can be used in different sectors, including heating, electricity generation, and transportation. Green hydrogen could be a vital solution because its generation process is based on splitting the water into hydrogen and oxygen using renewable energy. Additionally, hydrogen could be used to generated synthetic fuel, that has less negative impact on the environment.
- Monitoring individual households 'energy consumption: this could be achieved through smart meters and artificial intelligence, that is fundamental to analyse the huge quantities of produced data around the power grid and taking immediate control decision. This will change our way of energy consumption. For instance, energy companies will control the operation

of household appliances instead of you, based on the availability of energy.

Conclusions

Demand for energy is increasing across the world due to the rise of population and urbanization. Thus, there is an urgent need to offset this growth of energy demand through energy efficiency. The world is facing two main challenges, presenting by the way of how the world will deal with the rise of energy demand and with the transition of our energy system toward low carbon energy sources. The current paper presented the current situation of the global energy sector and examining the potential of renewable energy. Renewable energy could play a crucial role in dealing with the global challenge facing the global energy demand. The integration of renewable energy in the global energy system faces many challenges in terms of infrastructure, policies and regulations, and skills and institutional capacities. Fortunately, there are many solutions that could deal with the challenges, such as tripling investment in renewable energy sector, monitoring individual household, transferring energy subsidies from petroleum to renewable energy, and liberalize renewable energy technologies.

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