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Global Challenges to Sustainable Renewable Energy Expansion: The Funding and Incentives Structures

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The main barriers to expanding renewable energy (RE) globally have been insufficient financing and incentives. It will take dynamic strategies to make up for this deficit. Examining the impact of financing and incentives on regional, national, and global RE, technological advances, and policies by private and public actors is the focus of this work. Certain search terms were used across five academic databases from 2007 to 2022 and screened articles, reports, and editorials, where 82 publications were obtained for analysis. With 1,200 GW of installed solar, wind, hydroelectric, and biofuel capacity, China is noted to be leading the world. The RE installations were sparked by major shifts in private financing, incentives, policies, and targets such as the removal of import and value-added taxes. The 2017 launch of the energy code in India helped build solar and biofuel systems up to 100 GW. From 2010–2019, many nations adopted auctions, Fit-in tariff/premiums, renewal portfolio standards, and power purchase agreements, which aided the development of RE. Insufficient funding by public and private investments caused solar and wind energy to decline between 2010 and 2015, which may be related to price effectiveness. A significant rise for solar in 2016 and for wind in 2019 was noticed when funds were provided. The analysis proposes that YieldCos which operates RE assets be created/used to consistently provide funds to expand RE technologies and installations. Crowdfunding can be established to offer alternative sources of finance for small-scale RE projects. Also, green bonds and banks are feasible fiscal instruments with good policies that can be used to generate sustainable funding for RE development. The appraisal of the fit-in tariff, as well as the intensification of tax breaks, green certificates, metering, and subsidies, are essential incentives that can help encourage RE expansion.

1. Introduction

Due to the externalities of fossil fuels, the world is experiencing the challenges of pollution explosion and global warming. Concerns are also raised about the depletion of fossil fuels. As the global population increases and industrialisation continues, the need for clean energy to reduce carbon emissions grows (Dudin et al., 2019). As a result, a greater increase of investments in renewable energy (RE) supplies is needed (Sen & Ganguly, 2017). Due to the acceptance of RE, for instance, solar and wind energy, expanding RE in developed and installing in developing countries is critical to addressing the problems of carbon discharges and creating a greener future. RE has various advantages, including lowering greenhouse gas (GHG) emissions, reduction of dependency on fossil fuels, and improving energy security (Winkler et al., 2017). A major barrier to the expansion of RE is insufficient funding and poor incentive structures. Despite several RE funding sources, such as the World Bank (Devlin et al., 2017), regional banks, commercial banks and financial institutions, public and private sectors, and institutional investors (Ng and Tao, 2017), such as pension funds, insurance companies, and sovereign wealth funds that have spurred RE installation in many nations (Durrant et al., 2018), demand remains high. Whether on a global or local scale, RE has a high initial cost (Arefeen et al., 2021). To finance RE projects, it is vital to have sustainable, specifically designed RE funding sources.

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The aim of this article seeks to contribute by proposing sustainable strategically organised funding sources, enhancing specific incentive systems, and feasible policies to accelerate the installation and adoption of RE. This will aid in meeting the 2015 Paris Agreement targets of reducing carbon emissions and pollution and solving energy security issues by 2050. The objectives are to explore the progress and challenges in expanding renewable energy (RE) sources around the world with a focus on funding and incentivising. It examines both successful and unsuccessful case studies, paying attention to nations, regions, technology, policies, and incentives. No related work has been conducted and this makes the novelty and contribution RE financing.

2. Methodology

This study assessed articles from Google Scholar, IEEE Xplore, the Web of Science, Science Direct, and Springer that were published in energy reviews/reports, journal articles, conference papers, and editorials. The first search terms included "RE energy types", "regions/countries with strong RE", and "global RE installation and generation". This yielded 283 articles. A second round of screening was conducted using "global RE financing", "RE technology targets", and “RE policy and incentive instruments”, and obtained 121 papers. In the last screening, the terms "the impact of RE private/public financing," "Impact of incentives on RE installation", and "Global challenges in green energy funding", were utilized. Each article that was entirely examined was published in English covering from 2007 to 2022. As shown in Figure 1, a total of 82 papers were finally obtained with the highest number of 11 published in 2017, 10 in 2018 and 9 in 2016.

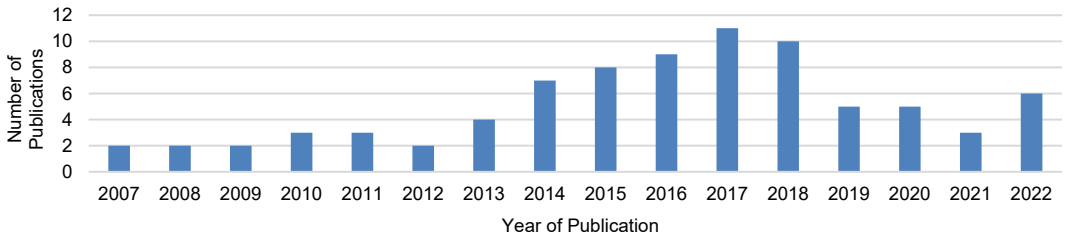

Figure 1: Year and Number of Publications

3. Results

3.1 By Region

For RE to expand, different financing and incentive strategies, technologies, goals, and policies must be adopted (Griffiths, 2017). Figure 2 shows the distribution of RE generated in six regions around the world by 2022 (IRENA, 2023). The installation, generation, and utilization of RE are highest in Asia, then Europe, North-America, and South America, and minimal in Africa and the Caribbean. Feed-in tariffs (FiTs), power purchase

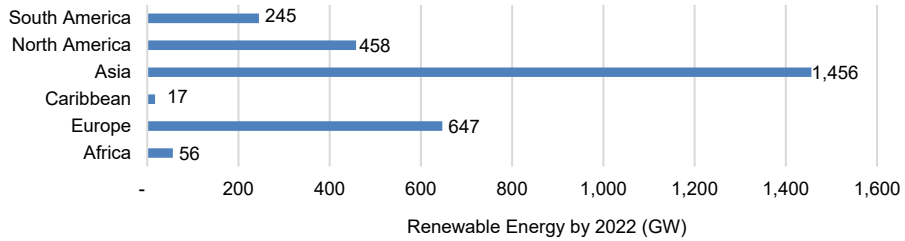

Figure 2: Regional Spread of Renewable Energy Generation (IRENA, 2023)

agreements (PPAs), investment tax credits (ITCs)/production tax credits (PTCs), grants and subsidies, net metering, renewable portfolio standards (RPS), low-interest loans, and capacity auctions have been used in these regions witnessing a steady expansion. The effectiveness of RE technologies may differ in each region depending on specific factors and the level of development of RE in each country in the region. For instance, the aggressive approach to incentives, policies, and goals in China, Japan, and India might have stimulated RE investment in Asia. In Europe, due to changes in FiT, FiP, and the number of auctions in Germany and the United Kingdom, must have increased the number of installations. In North America, the installation of RE in the United States and Canada slowly improved, attributed to the change of PPA to ITC. Brazil, Chile, and Uruguay in South America invested heavily in bioenergy due to improvements in tax exemption incentives. The literatures were unable to explain why there are few RE installations and adoptions in Africa and the Caribbean. The

primary barriers could be a lack of infrastructure, limited finances, imagined funding hazards, policies and law enforcement insecurity, absence of qualified skills and information, property rights and authorization issues, and subsidized electricity and reliance on petroleum. Others could be the lack of fiscal and investment aid, technology and skills development, policies and compliance support projects, collaborative agreements, R&D partnerships, geographical cohesion and electric power interconnection, and campaigns alongside public education. Through global collaboration all have the potential to facilitate Africa and the Caribbean's shift to a greener and greater renewable energy future.

3.2 By Country

In the past 10 y, the global RE development portfolio in the solar sector has been very large with an average annual growth rate of more than 50 % (IEA, 2023), the highest of all other energy technologies aside hydropower. Figure 3(a) shows the installed renewables in eleven top countries in 2022 totalling 2,105 GW (IEA, 2023). The literature simply associated the achievement with "good incentives, financial strength for investment, specific goals, and policies", with no actual instances or clarification on these aspects. For instance, China ranked first in the world with an installed capacity of 1,200 GW from solar, wind, hydropower, and bioenergy. This is due to the introduction of lucrative FiTs for solar power providers that regulated the cost of solar energy for a specific duration. Rebates decreased the costs for residential/business solar energy systems, aiding solar energy projects. These funding, incentives support and government regulations ignited the high volume of national solar technology manufacturing, installation and exporting, making China the foremost nation in the production of solar technology. The United States installed 300 GW (REN21, 2019) with the support of the implementation of numerous state-specific subsidies such as the ITCs in the California solar and PPA in the Texas wind energies projects. These lowered the tax burden of RE developers, and promoted greater funding in the industry, making the USA one of the RE leaders at the domestic and regional levels. Brazil with 150 GW from hydropower and bioenergy was driven by RPS, biofuels mandates and auctions. Canadian hydropower, wind and solar installations were afforded by PPA. India had a RE of 20 GW (IRENA, 2023), but when it declared a national solar mission in 2010, solar, wind and small hydropower plants installed 100 GW of RE by 2022. This was achieved by viability gap financing (VGF) allocated to solar power installations to mitigate the cost difference, increasing their attractiveness to individual financiers and developers. Net metering was utilized in a few provinces to enable solar consumers to get credits for surplus production as it transfers extra solar power to the electricity grid reducing their electricity bills. Japan used FiT, subsidies and PPA on solar and wind, tax on bioenergy and installed 100 GW. The United Kingdom employed renewable obligation on offshore wind and solar to get 50 GW. France installed 50 GW of wind and solar with the help of legal stability and tax payments. While Russia, Norway and Turkey installed 30 GW each from hydropower, solar and wind inspired by auctions, subsidies, and FiTs. RE expanded significantly in Germany with solar capacity accounting for more than 9% of the country's electricity generation by 2020. The regular revision of FiTs and EEG provided sustainability for the funding of the solar sector. This is reflected in Germany's strong rise in solar power projects, which produced 32 GW by 2012 and reached 65 GW by 2022, making it among the global major solar industries. Solar energy has risen significantly in various countries due to the distinct strategy and a blend of funding policies, financial incentives, and legal structures, still inadequate in wind and bioenergy technologies which needs finances.

3.3 Technology

As shown in Figure 3(b), the percentage of power from the 11 nations by different sources installed and generated in 2022 displays that hydropower installation and generation is the highest driven by FiTs and tax incentives. This is followed by solar, motivated by FiT and ITCs; wind is driven by FiT, production tax credit and

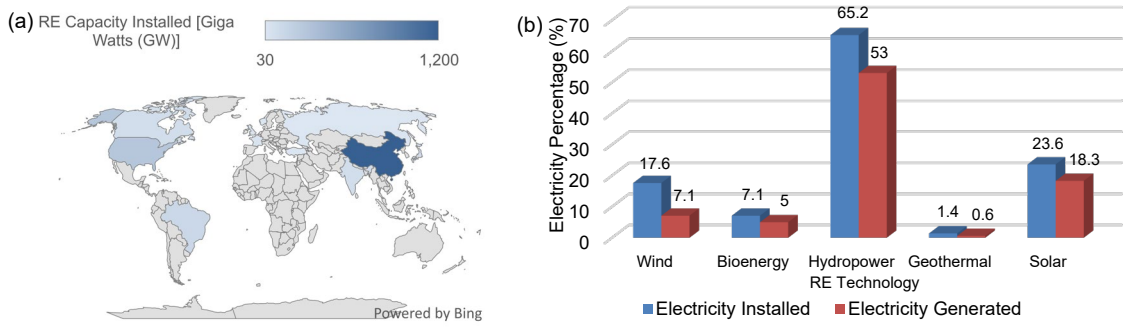

Figure 3: (a) Capacity Installed Renewables in 11 Top Selected Countries, 2022 (IEA, 2023), (b) Percent of Global RE Electricity Installed and Generated, 2022 (IRENA, 2023)

RPS; biomass spurred by tax credits, grants, and mandates; and geothermal energy stimulated by grants and low-interest loans. China's desire to reduce air pollution caused by coal-fired power generation greatly promoted the development of solar and wind energy. Since Brazil passed a law in 2007 to establish a solar energy mandate, 60 % of its energy has been provided from bioenergy and small from solar energy. In India, the revised "Code for Energy-Efficient Buildings" issued in 2017 (Klemes et al., 2018) contributed to the country's expansion of the use of bio and solar energies to attend the energy requirements of 20 % - 40 % of new buildings, cold climate zones, guesthouses, and clinics within the nation. It is observed that few nations are achieving RE installation demands while others lack or have insufficient funding and require a robust and smart finance plan.

3.4 Policies and Incentives

By the end of 2018, about 72 countries around the world had set RE targets (BP, 2021), and by now many more countries have adopted RE targets in different RE sectors. Policies and incentives like regulations, fiscal incentives, and auctions have been observed to be used in many different countries. Figure 4 shows the types of energy incentives used in RE development. From 2007 to 2019, FiTs/Premium incentives grew steadily, while investment/product tax credits fluctuated. Reduction in sales, energy, value-added tax (VAT), and reduction in carbon dioxide (CO_2) became prominent from 2009 to 2019. More countries adopted auctions from 2010 to 2019 which promoted the growth of RE.

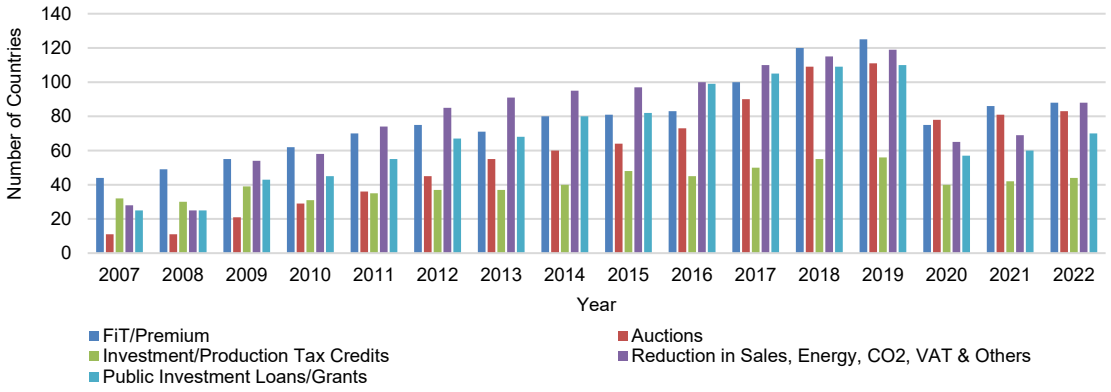

Figure 4: Incentives Used for Global RE Expansion (IRENA, 2023)

In 2018, Germany switched from on-grid electricity prices to auctions and employed a tax holiday from 2015 to 2017 where solar prices dropped, and installation increased from 128 MW in 2016 to 200 MW (BP, 2018). Spain, India, Chile, the UK, and the USA used renewal portfolio standards (RPS), FiT and auctions (Silva and Nasirov, 2017). South Africa signed a PPA, but could not implement it, and failed to achieve its solar technology goals for 5 y. The Economic Community of West African States (ECOWAS) adopted a quality assurance framework (QAF) for off-grid equipment but could not sufficiently support investors with funding (Mazzucato and Semieniuk, 2018), recording poor RE installation in the region. The PPA (Barbosa et al., 2017) and QAF (Tongsopit et al., 2017) approaches were used and eliminated the sales of low-quality products, especially in the off-grid solar product market. Incentives such as FiT and the exclusion of VAT, and import duties stimulated the installation and generation of RE in China and Germany (Buchner et al., 2017). Sweden abolished VAT on bioenergy and imposed a carbon tax on fossil fuels but installation slowed due to a shortage of funding. Denmark changed FiT from 5 to 10 y to support bioenergy generation. The United States stopped FiT and used preferential tax policies since 2017 as an experiment, of which 30 % was used for solar and geothermal energy, and there was a positive development in solar energy. In the UK, renewable heat incentives (RHI), and production-based incentives replacing FiT were introduced for commercial and manufacturing investors then expanded to housing (Fan, 2022). The RHI's goal provided profits and rewarded certain renewable technologies which cut higher capital costs.

Figure 5(a) shows the global RE investment from 2007-2022 (BP, 2022), in which hydropower is the highest with funding of more than USD14,000 M in 2012. From 2013 to 2015, most countries had policies and incentives changes, which affected investment and power generation (Chandel et al., 2016). These may have been caused by insufficient funding from the public and private sectors. When funds were supplied in 2016, an increase was noted especially in solar power. From 2017–2019, public and private investments declined in solar and wind energy, which may be due to various government goals and cost efficiency. As shown in Figure 4, from 2020 to 2022, all incentives were reduced, and retarded investment within the same period as shown in Figure 5(a), due to COVID–19 pandemic which badly hit the world of RE.

The RE funding and incentives durations vary from country to country which affected installation and distribution, for instance, in the UK, FiT was between 5 and 10 y (BP, 2022). Since financing, incentives, policies, and targets are powerful lubricants for the development of RE on a global scale, it is important to review them regularly and develop some more to expand RE. This will help to boost energy security, reduce energy costs, and protect the environment from global warming, environmental degradation, CO_2, GHG emissions and provision of jobs. As shown in Figure 5(b), the global net employment at the end of 2018 rose to 9.8 million due to solar PV power installation which increased by 47 %.

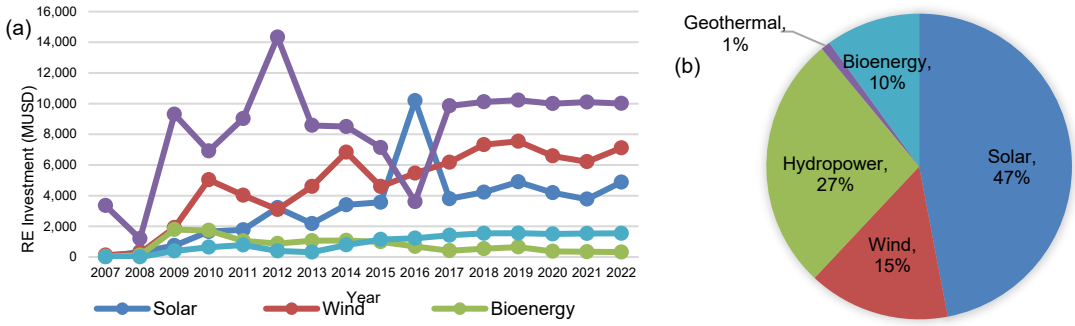

Figure 5: (a) Renewable Energy Investment Trend (BP, 2022), and (b) Global Renewable Energy Employment 2018 (BP, 2022)

4. Discussion

With the progress in RE, the development in advanced countries still faces challenges in funding, incentivising, and inconsistent market prices. Emerging nations also encounter limited funding and public acceptance/awareness, policies, and shortage of capacity. The deficiency of appropriately structured finances and strong risk mitigation tools have weakened the ability of RE to expand. Most countries and regions as have seen, employed public and private funding structures, thereby having shortages. In as much as these structures have merits, they also have demerits which include limited budgets, bureaucracy and delay, political influence, lack of flexibility, higher cost of capital, short-term focus, lack of social/environmental focus, and market volatility which can retard RE installation. Most incentives used were auctions, FiTs, PPAs, ITCs/PTCs, grants and subsidies, net metering, RPS, and low-interest loans. The duration for these incentives was very short in some countries such as in the UK and Denmark, where FiT was fixed for between 5–10 y. These made RE installations ineffective because they do not give RE manufacturers enough funding reliability and consistency. This review suggests that innovative funding structures like YieldCO which can provide an affordable form of finance to lower financing expenses and deliver a consistent income source can be employed to accelerate the growth of RE. Donation or reward-Crowdfunding and public-private partnerships (PPPs) can be introduced to offer alternative forms of funding for small and big-scale RE projects. Incentives such as green bonds and green banks, which have a duration of between 10–30 y and green certificates with a duration of one year can be introduced. PPAs, FiTs, RPS, and grants can be prolonged to between 15 and 25 y. These can provide enough consistency and fiscal security to motivate investors and promote clean energy projects enabling RE adaptability, advances in technology, and goals.

5. Conclusion

Analysis shows that the world has made progress in the development and deployment of RE, where solar and wind have growth rates of 23.6 % and 17.6 % by 2022. Incentives and policies including auctions, FiT, tax exemptions, carbon pricing, FiP, subsidy revisions, energy production payments, ITCs, and VAT have played a key role in the growth of RE most especially in China installing 1,200 GW, USA (300 GW), Brazil (150 GW), and India (100 GW) in 2021. Yet installation is insufficient. RE is still confronted with inadequate funding sources, unrevised incentives/policies in some regions, countries, and technologies which when consolidated it will protect early project growth risks and expand RE which is insufficient in developed nations and absent in developing countries where RE investments appear to have not grown. With the global demand for RE installation and expansion, this paper suggests the introduction of PPPs, YieldCo, Crowdfunding, green bonds, and green banks, an increase in the duration of tax holidays and FiT, upsurge in the percentage of rebates and grants, and the introduction of green certificates to eliminate funding barriers and improve incentives for RE expansion to achieve sustainable development. Next will look at financing long-term R&D to enhance RE technologies production and installation. The limitation of this paper is that, due to differences in RE

technologies, policies, funding mechanisms, and incentives across different countries and regions, this study's conclusions may not be immediately applicable to every situation or region.

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