An Analysis of Factors Influencing Renewable Energy Deployment in Developing Countries

Gaurav Giri

Administrator

Gaurav Infra, Nagpur, India

ABSTRACT

The research takes a starting point with the concept of renewable energy. We identify a diversity of factors and build the study to review the "Factors Influencing Renewable Energy Deployment" in the light of emerging economies with frequent references made to developed nations. The study's findings suggest that there are a lot of factors such as policy factors, technological progress, etc. that impact the large-scale 'deployment of renewable energy in developing nations, and the interdependence of such factors creates complexity for research. In this study, the policy factor section has especially aimed to address the research gap by conducting an exploratory study on the policymakers' approach toward renewable energy in developing countries. It is anticipated that energy experts, engineers, and decision-makers would find value in the study's results and suggestions.

Index Terms- Ministry of New and Renewable Energy (MNRE), Gross Domestic Product (GDP), Gross National Product (GNP), Human Development Index (HDI), The Global Subsidies Initiative (GSI),

Introduction

We use the word "energy" frequently without giving it much thought. It is applied in several different situations. Energy, in general, refers to a system's capacity to generate externalities, such as pressure along a route. When a body engages in or puts effort into work, its energy might shift. Here, energy may take on a variety of shapes, including:

- "electrical energy"
- "thermal energy"
- "mechanical energy"
- "magnetic energy"
- "potential energy"
- "radiant energy"
- "kinetic energy"
- "chemical energy" (Quaschning, 2016)

Our society depends on energy to support all other facets of our economy and to keep our level of living high. The supply of traditional energy sources including 'coal', 'oil', 'gas', and 'nuclear power' is limited. Pollution from conventional energy sources may take many different forms. Acid rain, greenhouse gases, and air pollution are a few of the more prevalent ones. Chemicals and particles are discharged into the atmosphere during the burning of 'fossil fuels'. Most of the energy
market is still dominated by conventional energy. Future energy consumption trends are anticipated to have negative effects on the environment, particularly in terms of acid rain, stratospheric ozone depletion, and the greenhouse effect multi-folding the severity than ever before. The majority of energy in the future will have to come from renewable sources (RE), as nuclear power is currently unlikely to grow its current tiny contribution (Moriarty and Honnery, 2012).

The fact that they not only harm the environment but also have a limited supply shows how dangerous our reliance on conventional energy is. We will soon run out of them if we don't reduce our usage. They can be risky in the long run in the case of careless use. Fossil fuel drilling is a risky process.

Our current environmental problems demand long-term projected initiatives for sustainable growth. In this regard, renewable energy sources appear to be one of the most sensible and effective options. Because of this, renewable energy and sustainable development are tightly intertwined.

Technologies for generating clean, abundant energy from naturally regenerating resources including sun, wind, earth, and plants are offered by renewable energy technologies. While most renewable energy sources are

sustainable, there are a few that are not. For instance, at the pace they are being used, some biomass sources are considered unsustainable.
Globally, the use of renewable energy has increased during the past ten years. Many developing nations are becoming more interested in implementing renewable energy programs as countries have made progress in developing their renewable energy resources (Gabriel, 2016). The majority of the world's electrical generation in 2020 came from hydropower (16.8%) and traditional biomass sources, with renewable energy making up only 29% of the total energy. About 12.2% of the US's total energy consumption and 20.1% of the nation's electricity production in 2021 came from renewable energy sources. Almost all developed nations have made considerable advancements in the production of renewable energy. More nations are considering producing renewable energy, which would enable them to become less dependent on fossil fuels and lower emissions. The following elements are also significant in indicating the massive push for the development of RE-based power generation:

- Cost: Compared to alternatives based on fossil fuels, RE technologies are typically thought to be less expensive.
- Availability: There are various RE sources accessible, and many nations have the capacity to produce their own RE sources.
- Reliability: Renewable technologies are a stable source of energy because they can be utilised as baseload power and can utilise existing transmission and distribution infrastructure, unlike other generation sources like natural gas that require costly new pipelines and transmission lines.
- Environment: Without progressive change in energy policy, emissions of 'greenhouse gases' (GHG) from burning fossil fuels will continue to rise (Black, Taylor Black, Solan, and Shropshire, 2015). The production of energy must drastically reduce its GHG emissions in order to meet increasingly strict GHG reduction targets. This might be done by expanding the proportion of renewable generation in the total mix of electricity output.

Around 30% of the energy utilized by people around the globe, including 20% of that from renewable sources, is electricity. Approximately 7% of energy consumption is still accounted for
by traditional biomass, however, this percentage is progressively declining. The utilization of modern renewable heat sources like solar water heating makes up over 4% and over 6% of all energy use, respectively. 'Solar', 'wind', 'solar biomass', and 'geothermal energy' technologies all continue to advance in terms of cost-effectiveness and are moving closer to becoming widely adopted. Global power generation from renewable sources increased from 26% in Q1 2019 to approximately 28% in Q1 2020. Coal and gas were mostly hurt by the rise in renewable energy, even though they still account for around 60% of the world's electrical supply.
As researchers and academics have identified renewable energy technologies as one of the potential solutions for the current environmental issue, a significant shift away from fossil fuels as the primary source of energy will be required due to the aforementioned reserve depletion and greenhouse gas emissions,
In a report only recently released by the Environmental Protection Agency, it was demonstrated how during the preceding 15 years, the usage of renewable energy in developing countries has increased significantly (Irfan, 2021). China and India have declared that they will construct sizable renewable energy power plants as part of their 'national climate action strategies' in recognition of such advancements. It is unclear, though, if these initiatives will have a long-term impact on a nation's energy security. The implementation of renewable energy is influenced by a number of non-policy factors, but new laws and incentives from the government are mostly responsible for this rise. The cost of fossil fuels, technological advancement, and social acceptance are the three main variables.

Problem Statement and Gap Analysis
Due to cost and infrastructure countries struggle to deploy renewable energy. Among economic and financial difficulties for the expansion of renewable energy are variables including high start-up costs, a lack of financial institutions, and investors, competition from fossil fuels, and lesser subsidies in comparison to conventional fuel sources (Raza et al., 2015). These logistical obstacles make it more difficult for developing nations to power themselves sustainably with wind and solar energy and adopt renewable energy widely. Developed countries consume more energy than developing countries do. However, because cars use fossil fuels, wealth in emerging economies (like China) causes a rise in worldwide energy consumption as the economy of the country in question improves. Countries that use renewable energy sources can reduce their energy costs, become more resilient to price fluctuations, and slow down global warming. A country's decision to develop its renewable energy resources may currently be influenced by a number of non-sustainable factors, including political instability, widespread corruption, and an unreliable supply of fossil

fuels. The necessity to sustainably power rural settlements has taken a remarkable role in the deployment of renewable energy in developing nations. Although the growth of small-scale renewable energy is encouraging, the high cost of large-scale renewable energy poses a serious obstacle to its use in these regions. Meanwhile, it might be challenging to introduce renewable energy into these markets due to issues including a lack of a lack of a reliable network to transmit the electricity and variable output across time (Azhgaliyeva, 2019). Harnessing the energy dependency is crucial particularly right now since rising fossil fuel prices, brought on by the conflict in Ukraine, are crippling impoverished energy-importing nations. Renewable energy sources will become increasingly popular and widely used once the infrastructure supporting them expands. There has been an upswing in research on sustainable development in recent years. Often these studies focus on developed nations and concerns that don't apply to emerging countries. In light of these events, it would be interesting to conduct research on factors influencing renewable energy deployment in developing nations. By analyzing the studies on industrialized and emerging economies, along with their societal and environmental limits, this study fills a vacuum in the literature within the renewable energy domain. The proposed study will also make an effort to recognize and examine the notion of renewable energy, the determinants that impact the deployment of renewable energy, and the nature of the factors in order to understand how they influence in regards to developing nations.

Research Questions

The study will aim to provide answers to the following questions in order to achieve those set objectives:

- What precisely is renewable energy?
- What variables influence the usage of renewable energy in developing nations?
- How do the factors influence the application of renewable energy?
- What factors impact the usage of renewable energy in developing nations?

Sustainable development and renewable energy are closely related. The viewpoint of renewable energy in formulating plans for sustainable development for emerging economies is addressed in this study. With a research focus on India, the key constraints for the growth of renewable energy are evaluated. With the use of data depictions and illustrations, the relationships between renewable energy and its influencers are described. This makes it possible to carefully analyze the possibilities for future development and a win over sustainability.

LITERATURE REVIEW

"Renewable Energy" is energy that is derived from a broad spectrum of resources i.e. resources that can be regenerated naturally over time and are therefore considered to be renewable. If economic growth persists along the path, it has been on in recent decades, the world's energy demand is predicted to increase to 1000 EJ (EJ = 1018 J) or more by 2050 (Moriarty and Honnery, 2012). According to estimates, prior to 2016, fossil fuels such as crude oil, coal, natural gas, etc. contributed almost 85% of the world's primary energy needs (Quaschning, 2016). This is why developing nations are bound to seek solace in renewable energy to keep their energy generation in alignment with economic growth and the associated upsurge in demands. In this section, we study the existing literature in order to develop an understanding of renewable energy and the factors that govern its deployment and refer to it in the context of developing nations to fulfill the nexus of our research objectives.

Renewable Energy Sources and the Types of Systems That Can Incorporate Renewable Energy Sources

The self-renewing energy sources include "sunlight" (Photovoltaics PV), "wind flow", "geothermal heat" (earth's internal/core heat), and "wave and tidal currents" (Ellabban, Abu-Rub and Blaabjerg, 2014) and "biomass" such as "energy crops", "agricultural and industrial waste" and etc. These resources can be leveraged to provide "fuels for transportation", "heat for buildings and industrial operations", and power for all the economic sectors (Bull, 2001). Bull also highlights that each renewable energy technology is in a distinct phase of research, advancement, and
commercialization. They also differ in terms of predicted costs for the present and the future, the existing industrial base, the availability of resources, and any potential effects on greenhouse gas emissions (Bull, 2001).

In this regard, Lund's book titled "*Renewable Energy Systems"* can enlighten remarkably. The technologies that transform natural resources into practical energy services are what he refers to as renewable energy sources. Let us have a look at how he articulated these 'natural sources'-

- "Hydropower", "wave", "tidal", and "wind" (including *micro- and river-off hydropower*)
- 'Solar energy' (including *photovoltaic/PV*), "solar thermal energy", and "geothermal energy" Technologies for "biomass and biofuels" (including *biogas*)
- Renewable snippets of waste' (*household and industrial waste*)

(Lund, 2014)

Delving more into waste-based sources of renewable energy, he points out that different sorts of garbage make up both industrial and household waste. Some components, like potato peels, are regarded as renewable energy sources, whilst others, such as plastic goods, are not. Usually, the term only takes into account the portion of waste that is replenished organically (Lund, 2014). Volker Quaschning makes an interesting effort to categorize renewable energy into solar, planetary, and geothermal. Following is a breakdown of the world's potential yearly energy supply from these three sources: "Solar energy" - 3,900,000,000 PJ/a "Planetary energy" (gravitation) - 94,000 PJ/a
"Geothermal energy" - 996,000 PJ/a (Quaschning, 2016)

Solar Energy

"Solar energy" is "light & heat" (electromagnetic radiation) from the sun that is processed by a multitude of methods, including "solar power to produce electricity", "solar thermal energy", and "solar architecture". The sun is by far the most abundant source of renewable energy. Each year, the sun sends 3.9 10 24 J = 1.08 10 18 kWh of solar energy to the earth's surface. This number is much larger than all known energy reserves and is over 10,000 times bigger than the world's primary energy requirement. We could provide all of humanity's energy needs from the sun if we could just manage to capture 1/10,000 of the incident solar radiation on Earth.

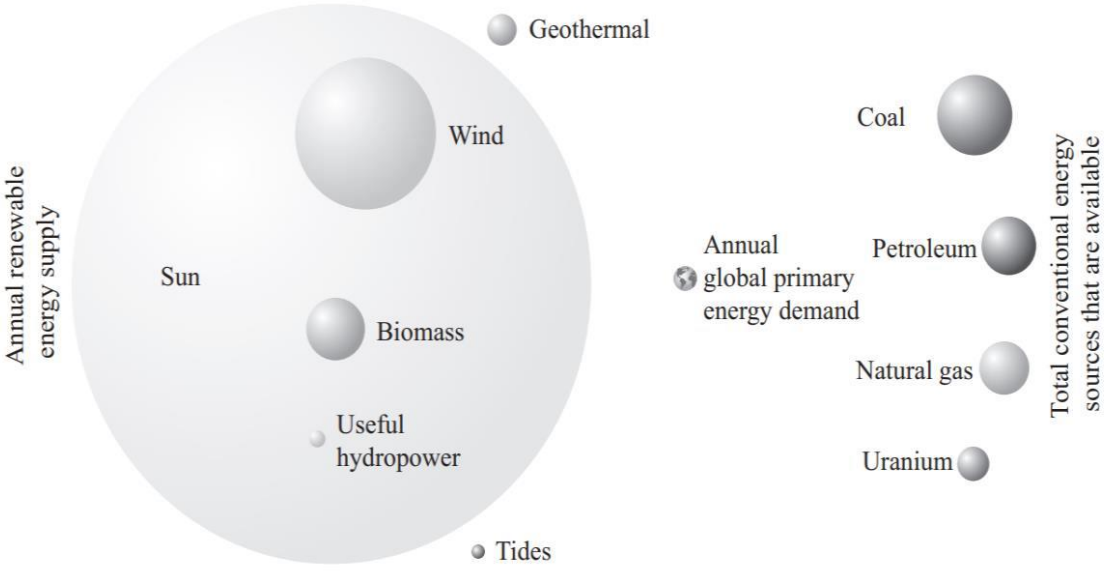


Figure 1: "Energy circles. The amount of incident sunlight that reaches the earth each year exceeds both global annual energy consumption and total energy reserves many times over."
Source: (Quaschning, 2016)

The most widespread sort of solar energy system that uses sunlight to generate electricity is the *'solar photovoltaic system'*. Among the other main forms of solar energy are:

- *"Solar-powered water heating systems"*
- *"Concentrated Solar"*
- *"Technical Passive Solar Heating"*

In his book "*Understanding Renewable Energy Systems",* Volker discusses various methods of directly and indirectly harvesting solar energy which is highlighted here. Direct use of solar energy includes – "*solar thermal power plants', 'solar collectors for heat supply', 'photovoltaics – solar cells that generate electricity',* and *'photodissociation for fuel production"* while some of the indirect forms of solar energy are- "*evaporation, precipitation, flowing water', 'the heating of the earth's surface and the atmosphere', 'wind', 'ocean currents', 'waves', 'melting snow'*, and *'biomass growth"*.

Solar energy may be used in a variety of indirect ways, including **hydropower.** One of the oldest and most significant forms of renewable energy is hydropower, also known as hydroelectric power or hydroelectricity, which employs the power of water in a natural motion, such as water running over a waterfall, to produce electricity. The largest form of renewable energy generation worldwide today is hydropower.

"Planetary Energy"

The earth is subject to the gravitational pull of the planets, but the moon has the most impact on the globe. During ebb and flow, enormous quantities of energy are required to move large masses of water. This oceanic energy may be captured by tidal power plants and used to produce electricity. Water runs through turbines into a basin during high tide, and at low tide, the water flows back through the turbines and into the sea. The turbines generate power as a result. However, tidal power plants are only able to produce a little amount of electricity.

"Geothermal Energy"

The term "geothermal" is derived from the Greek terms "geo" which means "earth" and "thermos" which means "heat". "Geothermal energy" is hence the art internal heat energy. Heat continuously moves from the inside to the exterior of the planet because of the large temperature differences between the crust and the core. This heat has nearly the same amount of energy as the world's primary energy needs. However, in order to tap geothermal energy, high temperatures must be maintained. Drilling can be used to reach these depths. Only years with geothermal animals are commercially attractive for geothermal energy. Such situations allow for the exploration of energy at relatively shallow depths since temperatures are high enough. Natural energy conversion results in the energy forms of wind and precipitation. They are capable of supplying fuel, power and heat. These sources, however, are quite erratic. Using wind energy mostly involves using wind turbines to produce power. Every single windmill is a mechanical system. Wind turbines for the production of power have just recently entered the mainstream. Aside from developed nations such as the US paint Germany and Denmark, India and China have the greatest wind power potential.

Volkar also demonstrates that the yearly supply of renewable energy could theoretically meet the world's energy needs by orders of magnitude. However, the switch to renewable energy is not straightforward. We need to establish a radically different energy industry from the one built in the last several decades if we wish to employ renewables extensively. Fossil fuels make up a major portion of the traditional energy market. Currently, it is intended to harvest, transmit, and transform it into various types of energy at central facilities as inexpensively as feasible. If renewable energy sources make up the majority of the energy industry, then assuring energy availability must also be a priority in addition to just converting one kind of energy (such as fossil fuels into electricity). Among the options are large-scale energy storage, international energy transportation, and demand management, which involves adjusting energy usage to supply. (Quaschning, 2016)

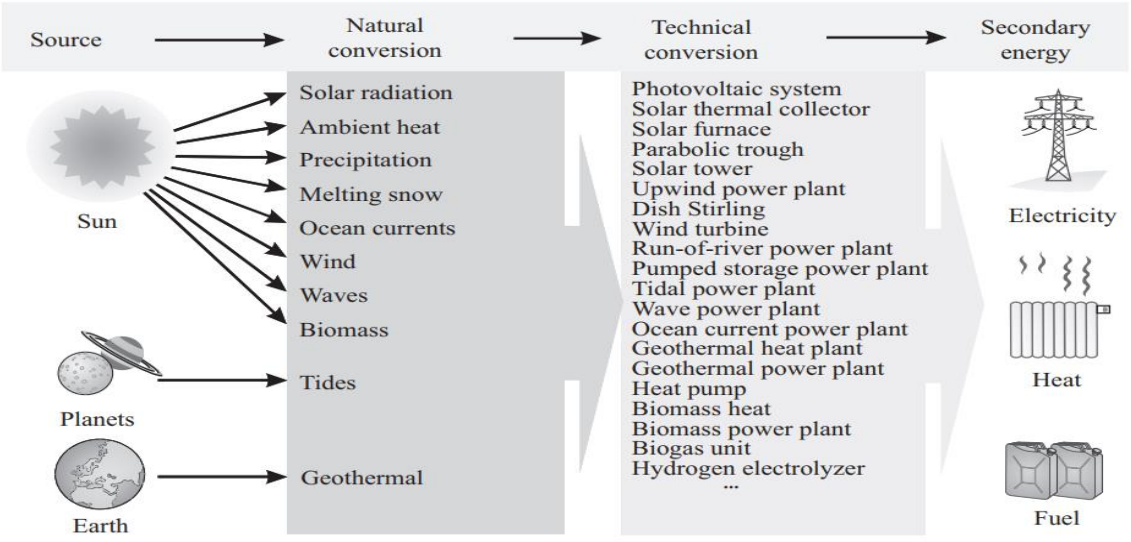


Figure 2: Sources and Ways of Using Renewable Energy
Source: (Quaschning, 2016)

Applications, Environmental Considerations, and Socio-Economic Factors of Renewable Energy Systems in the Context of Developing Nations

Energy is pivotal for the growth of economy as well as sustainable development which requires renewable energy sources (Hunjra, Azam, Bruna and Taskin, 2022). There has been a influx of studies on the correlation between "energy production and economic growth", especially since the acclaimed work of Kraft in the United States (Kraft, 1978). Wealthy nations have seen consistent advancement in recent years, with renewable energy penetration exceeding double-digit proportions throughout various countries' power output, but underdeveloped countries are still in the early stages of producing renewable energy (Østergaard et al., 2020). With non-renewable energy providing more than 87 percent of the developing world's energy needs, it has lately maintained its position as the most popular power source. As a consequence, sources such as fossil fuels and other non-renewables disseminate CO2. In fact, less than 20% of the energy extracted in developing nations comes from renewable sources while the majority originates from fossil fuels. Given non-renewable fuels are the major source of pollution, emerging nations are now focusing on enhancing their industrial practices and energy usage in the wake of prior disasters.
A 2022 study that used an unbalanced panel data approach to examine the potential for "sustainable economic development (SED)" in 50 "low-income countries" and "middle-income countries" from 1991 to 2020 found that financial development, the abundance of natural resources, and institutional quality all have a beneficial impact on SED (Hunjra, Azam, Bruna and Taskin, 2022). India still falls under the World Bank's purview of a "lower middle-income country", with an average annual income of an Indian being $1,935 in 2020. The notion that energy consumption is not evenly divided across the so-called wealthy and poor economies is the foundation for conversations on the environment and development at the United Nations. Due to the fact that renewable energy (RE) has emerged as a major influence on countries' energy policies and is frequently seen in politics, business, and academia as the primary solution to the world's climate problem, it is critical to address the significant obstacles in the investment climate for RE in emerging economies.
Currently, it is believed that the link between gross energy consumption and the gross domestic product is robust and consistent (GNP). It follows logically that energy metering is a risky proposition for policy since it would lead to the deterioration of economic activities (Kraft, 1978). Market expansion, technological development, and public policy are all closely related to the growth of renewable energy (Gross, Leach and Bauen, 2003). Market expansion, technological development, and public policy are all closely related to the growth of renewable energy (Gross, Leach and Bauen, 2003).

Policy Factors
This 2022-book titled as "*Building Innovation Capabilities For Sustainable Industrialization: Renewable Electrification In Developing Economies"* makes the case that local economic growth may benefit significantly from renewable electricity in underdeveloped nations, but rather innovative methods are needed to make these potential a reality. (Lema, Andersen, Hanlin and Nzila, n.d.). Taking the case of India, there are several geothermal springs and seven geothermal regions. Even though India was one of the first nations to start geothermal projects back in the 1970s, the country currently has no geothermal facilities that are in operation. The "Ministry of New and Renewable Energy" (MNRE) of *Govt. of India* estimates that India has the capacity to produce 10 GW of geothermal energy.
A recent study (based on panel data spanning 66 developing nations between 1984 and 2019) on the "Impact of institutional quality on sustainable development" demonstrates that institutions have a larger influence in lower-middle-income countries as policymakers recognize that effective "Environmental Resource Management" is a critical threat to "Sustainable Development" in these countries. According to research, two of the key policy implications are that in order to create effective and successful environmental resource management policies, institutional enforcement of the law and varied 'institutional form' is required (Azam et al., 2021). Exploration and exploitation of India's geothermal energy resources are priorities for MNRE. With a total government financial assistance of Rupees 34,422 Crore, encompassing service fees to the instrumental agencies, the MNRE has set the 2022 goal for accelerating the deployment of renewable energy.

Several non-policy elements affect whether or not renewable energy is used, even though it is acknowledged that the deployment of renewable energy is primarily depends on new government policies and incentives. The cost of fossil fuels, technical advancement, and societal acceptability are the other three main factors.

Price of Fossil Fuels

Renewable energy is being utilized more often in emerging nations now more than ever. Because fossil fuels are less accessible and more expensive currently than they once were, renewable energy sources are more economical. For usage in buildings, companies, and industries, fossil fuels are utilized to produce heat and power. Fossil fuels till now have constituted vital resources that many people to count on for their livelihoods. Yet using them also produces damaging "greenhouse gas emissions" that has a dampening effect on global warming. The cost of fossil fuels is rising, and this has a significant influence on how governments throughout the world regard renewable energy. Due to the fact that renewable energy is created through natural processes like the sun's rays or the wind and does not have the same restrictions as fossil fuels, it is a viable choice for many consumers and companies (Shimbar and Ebrahimi, 2020). Although the sources of renewable energy are becoming more and more popular across the world, much of this increase has occurred in industrialized nations where the financing and technology required to use these resources are more easily accessible. The cost of fossil fuels has increased significantly over the last ten years, making renewable energy a more appealing alternative. According to certain government representatives, traditional fossil fuels are far less cost-effective than renewable energy sources. Additionally, as a way to cut carbon emissions and combat climate change, there is increased interest in the deployment of renewable energy sources instead of other power sources. This tendency is especially relevant in developing nations since the cost of fossil fuels is often much greater than in affluent nations, where oil can be cheaply exploited and coal mines are located nearby inhabited regions. For instance, a developing nation has blackouts every year during the height of the summer demand when they are unable to keep up with demand because there is insufficient supply from traditional energy sources (Xu, Chen, Feng and Tang, 2018). During this phase, the nation faces a critical need for domestically produced renewable energy to improve its energy security and lessen the "blackout" numbers that affect inhabitants annually. Though poor nations are now aware of the possibilities of renewable energy, the cost of this technology in comparison to the cost of fossil fuels may deter them.

Technological progress

The use of renewable energy in developing nations has been greatly impacted by technology. Renewable energy technology has made significant strides in the last decade. While a lot of people may contend that the growing accessibility of "solar panels", "wind turbines", and other similar technologies has aided in the expansion of these markets, others cite that developing nations are more inclined to invest in renewable energy sources if they have limited access to dependable electricity which makes for good reasoning to justify the boost alternative energy deployment given the market conditions and price hikes all over the world. Most affluent nations provide 24-hour access to energy, but in poor countries like Tanzania and India, power disruptions are disturbingly frequent (Polcyn et al., 2021). In addition, some customers may find renewable energy sources to be more pricey than conventional energy which cannot be denied. Government grants and tax breaks have a significant impact on how much renewable energy sources cost. For instance, the govt. subsidizes "wind" and "solar energy" by up to 50% in Indonesia and Thailand (two major economies in South East Asia), allowing renewable energy producers to sell their goods for less than they would otherwise be able to in general circumstances. The ways in which we produce and use energy are being fundamentally altered by a technology environment that is undergoing fast change. This tendency is more pronounced in developing countries, where renewable energy is becoming more popular than in any other area of the world. According to research, this rise is being fueled by both the respective governments and corporate sectors' initiatives to reduce energy reliance, as well as by more consumer access to renewable energy technology (Sari, Karaduman and Firat, 2015). To lessen their reliance on fossil fuels, emerging nations have been installing solar panels and wind turbines for the past 10 years. The business for renewable energy as a whole, which has been gradually expanding since the early 2000s, includes a sizeable portion of this. The development of technology has greatly contributed to the rise in the usage of renewable energy sources by lowering their prices and encouraging greater investment in the industry. But in many nations, ongoing financial obstacles have delayed or even halted its development.

Social Acceptance

To lower the cost and environmental effects of their energy systems, developing nations are rapidly implementing renewable energy sources. Over the past ten years, the cost of solar photovoltaic (PV) panels and wind turbines has declined dramatically, putting them on par with more conventional energy sources like coal and hydropower. China, India, Pakistan, Nigeria, and Indonesia, the five most populous emerging nations, produced a hideous 75% of their power from burning fossil fuels in 2014. (Lin, Omoju and Okonkwo, 2016). However, these five nations have added more new wind and solar capacity over the past ten years than any other area.

Although they have greatly increased in popularity as of 2016, fossil fuels are still more commonly used than renewable energy sources. Although the price of renewable energy has drastically fallen with the passage of time, it is still more costly than conventional power sources. This is much more apparent in poorer nations because many individuals cannot afford to purchase pricey energy sources. Increasing the social acceptability of renewable energy sources within a particular community is one approach to increasing the number of individuals who use them. The stages of the diffusion of innovation theory are the greatest fit for describing the societal acceptability of renewable energy (Mignon and Rüdinger, 2016). Everett Rogers developed the theory in 1962, and it has been applied to describe how ideas spread over time within a particular group. Before an idea is broadly embraced, it must pass through five different stages, which he describes:

1) No matter how valuable new ideas may be, "innovators and early adopters" are usually the first to give them a try.
2) The early majority will keep utilizing a concept if they think it has promise but won't test it out unless they know other individuals who have previously done so.
3) The late majority won't adopt a new concept unless they observe that the majority of those in their immediate vicinity are already doing so.
4) The very last group to accept a new concept is the laggards.

RESEARCH METHODOLOGY

Research Design

The research strategy used in the proposed study is an alternate one that is neither scientific nor systematic. It falls within the category of basic research. It identifies with constructionism as a philosophy based on secondary data. The review focuses on fundamental analysis, qualitative considerations, case studies, and examination of particular economies with the aid of secondary data. In order to make the available information more intelligible to decision-makers, it attempts to discover, assess, and synthesize the conclusions of all pertinent individual studies on factors influencing the adoption of renewable energy in developing countries.

The study makes use of important secondary sources of data with the justification that there are lessons to be learned. The secondary methodology aligns with the deductive approach because it involves analyzing additional pertinent research, such as those on the adoption of renewable energy in developing nations, to contextualize the findings of the major study (Fletcher, 2016). This method gives us a clearer view of our findings and guarantees their reliability. The secondary technique aligns with the descriptive and correlational research designs out of the five sorts of research designs — “descriptive”, “correlational” “experimental”, “diagnostic”, and “explanatory”—because all the data are gathered from already published papers, eBooks, journals, etc.

Tools & Data Description: The primary and secondary methodology are the two basic methods for analyzing the factors that impact the adoption of renewable energy in developing nations. Primary research involves gathering unique data for a specific purpose (in this case, interviewing an expert on the subject) from sources that have not been published or studied earlier. As its name implies, secondary research draws on previously published data (Kuecker, 2021). The study is based on information collected from the internet, databases, books, journals, and other sources and it is a work of another party and includes reading scholarly literature and articles on the subject, studies undertaken by academic researchers, or other renewable energy experts.

Surveying people who have solar panels put in their homes, and interviewing industrialists, scientists, academicians, policymakers, and other users to assess ‘social acceptance levels’ are typical examples of primary research in the renewable energy space. In similar studies, the Delphi questionnaire has been employed to investigate the economic, technological, social, and environmental factors that limit the applications of solar, wind, and biomass energy on a large-scale level with responses being evaluated with statistical tools such as mean, standard deviation, rank correlation, confidence, and skewness. Although primary data can offer a plethora of knowledge on a particular issue or subject, it is undeniably time-consuming, expensive, and difficult to collect.

It would be very difficult to perform an experiment or survey for this case study because it needs to concentrate on the “deployment of renewable energy” in different regions of India. Secondary research was chosen to investigate the factors that affect the implementation of renewable energy in developing nations as

it is economic, swifter, and able to provide a wide range of reliable and tested data without requiring the lengthy fieldwork that primary research demands.
Secondary research falls into two primary categories: quantitative and qualitative (Matovi and Ovesni, 2021). Examinations and experiments are part of quantitative research. Non-numerical data sources used in qualitative research include surveys, observations, and interviews.

Techniques for secondary research –

1. Since the data has already been thoroughly investigated and researched by various agencies, no particular techniques are necessary. Instead, the emphasis is placed on gathering and compiling the necessary data from reliable sources, such as research journals, business magazines, and government publications. The bibliography contains all of the cited sources.
2. Because we tried to achieve several goals, we have used a variety of published resources and validated our data in order to focus on the issues and factors influencing the deployment of renewable energy in emerging economies such as India and others.

The approach to content analysis of some of the latest developments globally in the renewable energy arena by reviewing recent blogs and reports strengthens it with a unique approach.

Data Collection:

Using India as a preliminary base, this research studies the landscape of renewable energy in the context of developing nations. The depth of literature, articles, journals, and review of other secondary sources assist with general mapping and upholds general patterns in the renewable energy approach. The case study will also highlight the difficulties and possibilities of changing the current energy systems to ones that place a larger focus on renewable energy. The fundamental technological and market breakthroughs in the four primary renewable energy sources—wind, wave and tidal, photovoltaics (PV), and biomass energy and their advancement in India—are covered in this paper. The "National Renewable Energy Laboratory"s documents give an analysis of the factors that affect the use of renewable energy in emerging nations. The report includes elements including price, technology, and legislation. The material cost of installation is how the cost is typically characterized. Any element of government strategy that encourages or discourages the development of energy from renewable sources technology is referred to as the policy. Any form of technology that may be used to produce electricity, such as solar systems, wind turbines, and hydropower facilities, is often referred to as technology.

Section 1: The statistics on renewable energy deployment, reports from government websites, databases such as "National Renewable Energy Laboratory", "Global Subsidies Initiatives", "International Renewable Energy Agency", and "World Bank" reports are reviewed, and a chunk of other reliable sources provide accurate and in-depth knowledge of the renewable energy initiatives globally and the Indian scenario.

Section 2: Case study - In our thesis, we applied the case study method. The case study entails macro-economic data of the country such as – GDP Per Capita, Household Income as well as market data such as the availability of natural resources like coal, and uranium and the economic value of these resources. Other focus areas revolve around technological progress and global price trends of fossil fuels in keeping with the research objective which is to study the factors influencing the deployment of renewable energy.

Section 3: This section extensively discusses the significant hindrances to renewable energy in developing countries as well as examines the extent to which Indian policies and regulations favor the prosperity of renewable energy in the country in relation to government subsidies and tax credits along with scanning environmental management programs and climate action reports and energy policies to a great magnitude.

Data Analysis Strategy

Analysis – In section 1, a major content analysis has been conducted in order to frame concepts on the topic of research and familiarize the general themes enabling manageable content categories for the rest of the discussion. The content analysis in section 2 enables us to identify the scale and structure of renewable energy in India. Supplementary data collections from government databases and credible websites aid the discussion. This data is thereafter analyzed with the techniques of qualitative research that in this case is comprised of data reduction (sorting/coding) and data display (charts/tables/illustrations/quotes).

FINDINGS & ANALYSIS

Section 1

The main driver of industrialization, urbanization, economic expansion, and societal quality improvement is electricity. Countries are forced to create efficient methods for energy mix due to the depletion of conventional supplies. Planning for and promoting research on various energy resources demands a fresh normative approach.

To get to this juncture, a number of international institutions back the deployment of renewable energy sources.

- "National Renewable Energy Laboratory" (NREL)
- "International Renewable Energy Agency" (IRENA)
- "World Bank"
- "Initiative for Global Subsidies"

Limitations in fuel flexibility, efficiency, reliability, costs, and pollution may be faced by these energy sources. To meet the expanding demands of developing countries, the energy mix needs to be revolutionized and new renewable energy sources (RES) introduced.

The energy sources may deal with restraints on "fuel flexibility, efficiency, reliability, economics, and emission". To meet the expanding demands of developing countries, the energy mix needs to be transformed and new renewable energy sources (RES) introduced. They necessitate a novel normative strategy for organizing and promoting study on various energy sources. The firms on the aforementioned list offer ongoing assistance with the process and product design as well as models and standards for creating a framework that enables successful implementation throughout the renewable energy area. We address this in this section through a study of their data and statistics. With the emergence of the concept and the passing of time, it is critical to reflect on fresh insights and act proactively in response to the most recent advancements and we address that in this section through a review of their data and statistics.

"National Renewable Energy Laboratory" (NREL)

To maximize the use of modern energy technologies for the power, transportation, construction, and industrial sectors and improve the performance of the whole energy system, National Renewable Energy Laboratory uses its knowledge globally.

According to the NREL approach, developing nations need to focus on the following components in order to implement power system market designs, regulations, and policies:

- "Innovative market structures and policies for regional system integration and power trading"
- "Energy system pricing"
- "Net metering and net billing"
- "Power purchase agreements"
- "Competitive renewable energy zones"
- "Cost recovery"
- "Standards and incentives for advanced electric vehicles and alternative fuel technologies"

Now let us analyze the recent developments critically with the help of NREL's extensive data library. The aim of this section is to cross-highlight the growth on the distinctive economic phase basis which is here the developed and developing nations.

As referred before that the sun is so far the most abundant source of renewable energy, in the below section we have outlined the statistics on the global deployment of solar to frame our discussion.

Global Deployment of Solar

For several top markets, in the first half of 2021, PV (photovoltaic) installations climbed dramatically year over year. By June end of 2021, the countries cumulatively saw a staggering number of PV installations which is nearly 497 GWDC of PV. (Solar Industry Update Fall 2021, 2022)

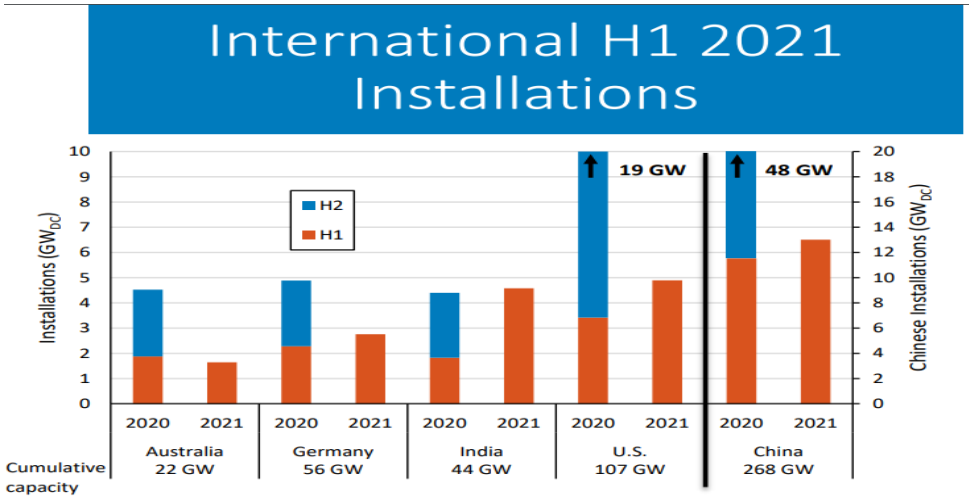
Developed Nations

The United States deployed 7.4 GW (10.8 GWoc) of PV in H1 2021, which is the highest total for half-yearly growth registered ever.

Developing Nations

In the first half of 2021, China deployed 13 GWoc.

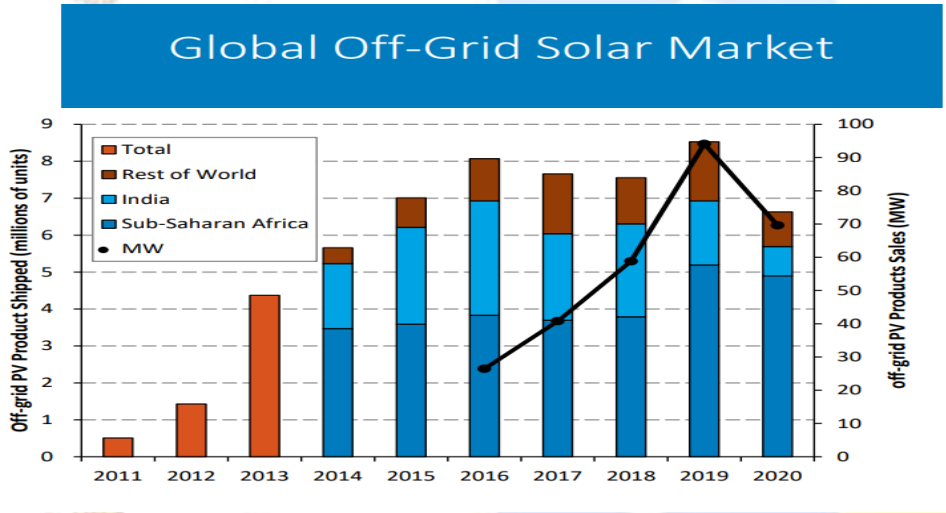
India, on the other hand, installed 4.6 GWoc in H1 2021, which is greater than it did in the entire year 2020.



Sources: Australian Photovoltaic Institute. IEA, Snapshot of Global PV Markets: 2021. Mercom (07/26/21 09/06/21).

Wood Mackenzie/SEIA: U.S. Solar Market Insight: Q3 2021

As per NREL Report, in the first half of 2021 alone, India has remarkably installed more PV solar than it did in the whole of 2020 which is to be credited to strategically targeted state-imposed lockdowns that better-enabled renewable energy developers to manage unforeseen circumstances. (Solar Industry Update Fall 2021, 2022)



Source: Global Off-Grid Lighting Association, "Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data."

India also stands out when it comes to the sales of off-grid solar with 12% of sales being from the country. The outcome of the Covid-19 pandemic has further highlighted the need for resilience in renewable energy development and its impact on the overall energy economy. The outbreak was accompanied by "regional lockdowns", "logistical and supply chain challenges", and "increases in hardware pricing" diminishing the sale of off-grid solar products. (Solar Industry Update Fall 2021, 2022)

In a global context, the covid-19 brought-upon dwindling serves as a stark reminder that the implementation of renewable energy requires a combination of robust leadership, long-term foresight, and progressive regulatory frameworks which make up for section 3 of this study on the policy factors for the deployment of renewable energy.

"International Renewable Energy Agency (IRENA)"

Other international technical institutions, organizations, and businesses from private agencies are funding energy research initiatives. In light of India's long-term planning, the International Energy Agency (IEA) which is another such body, believes that India requires a financial investment of a minimum of 135 billion US dollars to serve its population with universal access to electricity. Before 2050, India will adjoin an additional 600 GW to 1200 GW of new power production capacity, the IEA estimates. In 2009, India achieved a feat by having itself included among the Signatories founding members of the International Renewable Energy Agency". Upon welcoming its 77th Founding Member in the Preparatory Commission of renewable energy, the Chairman of IRENA's Administrative Committee cited: "The commitment of India to IRENA is a strong signal for a widespread and sustainable use of renewable energy." Chairman Karsten Sach also remarked: "Being one of the world leaders in renewable energy, India demonstrates that renewable energy and sustainable economic development go hand in hand." (India becomes 77th Member, 2022) While all the success of renewable energy in India is discussed, it gets increasingly interesting to look at the success enablers which is going to be our topic of study for section 2.

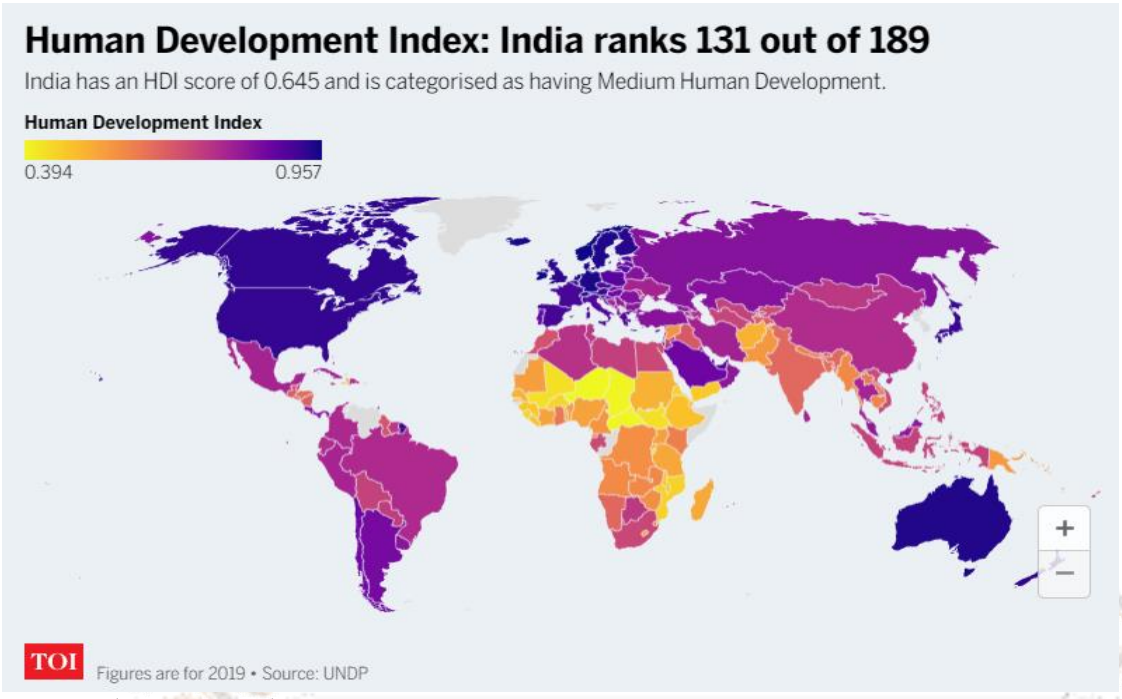
Section 2

A 2013-research has referred to India's electricity sector as one of the world's most active players in renewable energy utilization (Khare, Nema, and Baredar, 2013).

He pointed out that India produced 22.4 GW of energy using renewable technology, surpassing Austria's total installed electricity by all technologies, which is quite impressive from the perspective of a developing country (as of December of 2011). According to India's 17th electric power survey, industrial demand made up 35% of the nation's electrical power requirements in 2010–11. Domestic home use was in second place (21%), followed by agricultural use (21%), commercial use (9%), and other uses (the remainder). With a peak electrical demand, it is predicted that the consumption of electricity for 2021–2022 would be at least 1915 TWh.

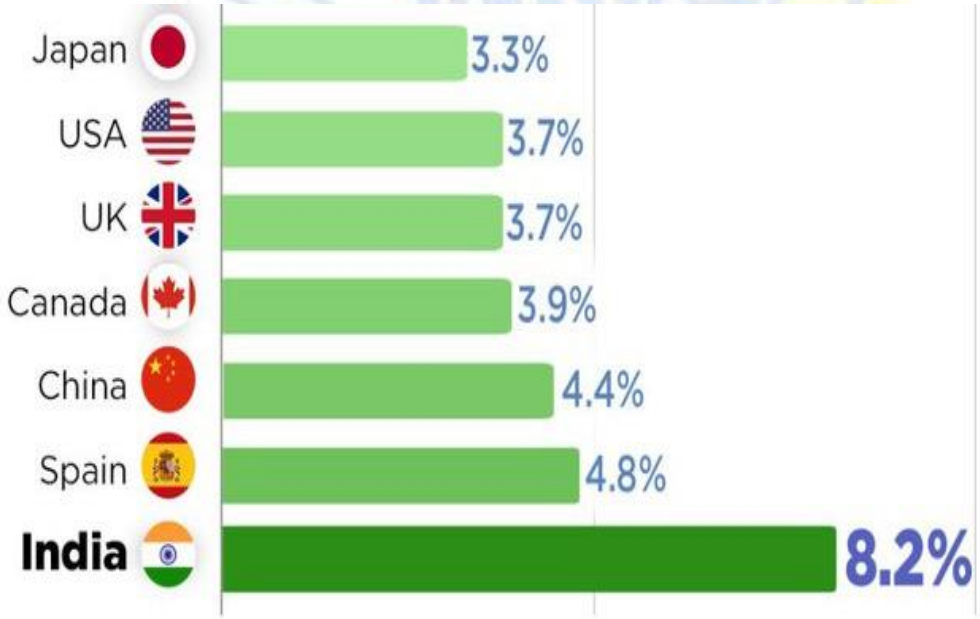
While on the surface, India's renewable energy sector has grown, it is of paramount importance to discuss the macro-economic factors and market data associated with renewable energy to meaningfully investigate how much it is in alignment with economic prospects and the hindrances, if any, and the variables that impact the deployment of renewable energy which will predominantly constitute our case study to seek answers to the stated research questions.

Even after many years of independence, India is still classified as a developing country because of its "low per capita income", "overpopulation living below the poverty line", "inferior infrastructure", "agro-based economy", "low rate of capital formation", and low "personal and household incomes". India is one of the world's fastest-developing nations. India started to relax its economic limitations in 1991, and the nation's private sector expanded as a result of the higher level of liberalization. However, the country's inefficient population and low rate of literacy continue to be a strain. India is characterized as having Medium Human Development and has an HDI score of 0.645. According to the most recent Human Development Report, India's HDI score is 0.645, placing it 131st out of 189 countries (News, 2022).



Source: (News, 2022)

When it comes to household incomes, households with annual incomes less than Rs.100,000 are at the bottom of the income gradient. The next segment, known as the lower middle class, makes between Rs. 100-200k annually. The third category of families is the middle class and earns between Rs 200k-500k annually. "IMF World Economic Outlook" (April - 2021) projected that India's Mominal GDP per capita to be $2,191 at current prices in 2021. Among 194 economies, India ranks 144th in terms of nominal GDP per capita. India's net national income, or NNI, per person, was approximately Rs.135000 in 2020. The gross measure of a nation's prosperity is its per-capita income. At constant prices, however, the gross national income was almost Rs.128 trillion. On the other side, India has a comparatively young population with the median age being 28. Furthermore, IMF has positively cited India as the fastest growing economy in the world.



Source: (IMF World Economic Outlook, 2022)

Given the mixed imagery the data evokes, it is essential to be aware of the following variables that are crucial for the prosperity of industries and the state of the economy: "microeconomic stability", "growth rates", "infrastructure", "unemployment rates", "inflation", "labor productivity", "regulatory frameworks", "tax and legal systems", "corruption", "quality of the educational system" and the "literacy rate", and "culture".

India is falling behind other countries in terms of literacy; its percentage is 74.04%. Not only the lack of technical expertise in the working population but also the lag in infrastructural developments makes it seemingly unfavorable for the further push into renewable energy. Unequal income distribution is another

burden for the deployment of renewable energy as it's a known fact that renewable energy is priced higher than conventional energy.

In the USA, the PV (solar) system component pricing somewhat stands at -
In 2020, the ambit in average U.S. PV system pricing across methods were reported to be:

- "$2.7/W to $3.7/W for residential"
- "$1.4/W to $2.9/W for nonresidential"
- "$0.9/W to $1.1/W for utility-scale"

(Solar Industry Update Fall 2021, 2022)

Whereas the pricing scenario for India is somewhat presented below –

Benchmark Costs for Grid Connected Rooftop Solar Power Projects for the Year 2020-21

Capacity**	Benchmark Cost for States Other Than Special Category States					Benchmark Cost for Special Category States including North Eastern States, Uttarakhand, Himachal Pradesh, J&K and UTs of Andaman & Nicobar Island and Lakshadweep				
	2020-21		2019-20		% of variation	2020-21		2019-20		% of variation
	₹/W	$/W	₹/W	$/W		₹/W	$/W	₹/W	$/W	
1 kW	47	0.63	54	0.72	-13.0%	52	0.70	59	0.79	-11.9%
Above 1 kW to 2 kW	43	0.58	54	0.72	-20.4%	47	0.63	59	0.79	-20.3%
Above 2 kW to 3 kW	42	0.56	54	0.72	-22.2%	46	0.62	59	0.79	-22.0%
Above 3 kW and Upto 10 kW	41	0.55	54	0.72	-24.1%	45	0.60	59	0.79	-23.7%
Above 10 kW and Upto 100 kW	38	0.51	48	0.64	-20.8%	42	0.56	53	0.71	-20.8%
Above 100 kW and Upto 500 kW	36	0.48	45	0.60	-20.0%	40	0.54	50	0.67	-20.0%

*Capacity will be calculated based on the inverter capacity or the SPV module array capacity whichever is lower

**The separate benchmark cost for special category states will be applicable for projects under phase II of the program only

Source: MNRE

Mercom India Research

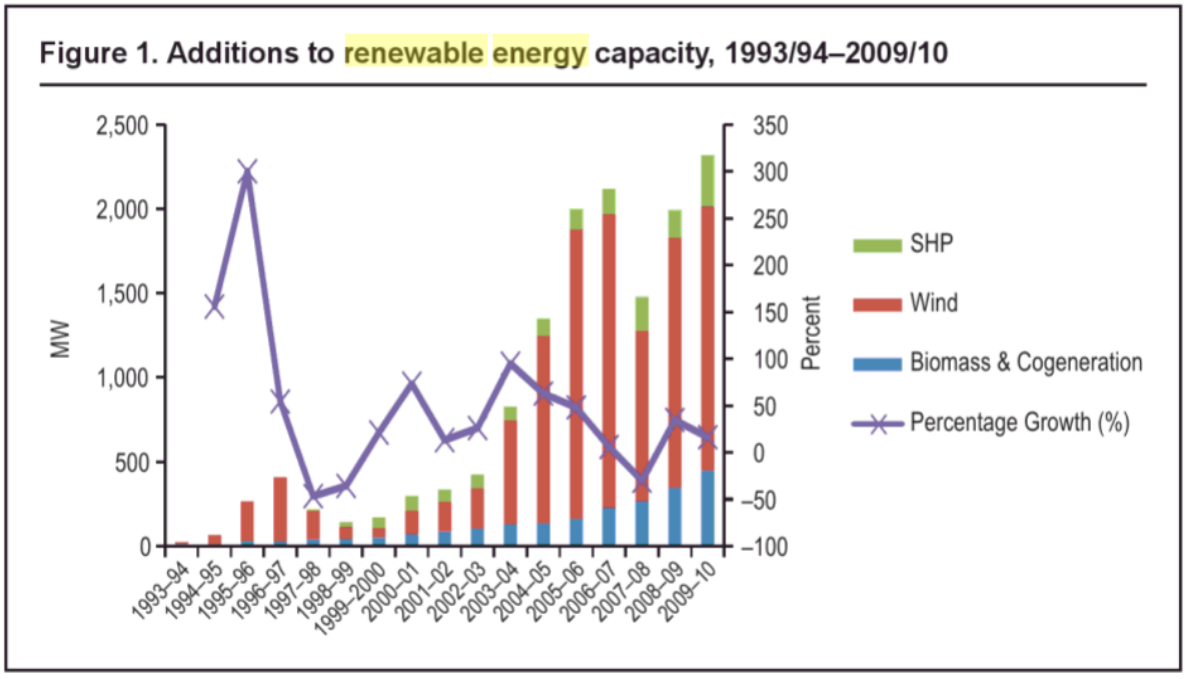
Source: Ministry of New and Renewable Energy

It is to be noted that strong institutional backing for the advancement of the renewable energy sector is noted in India with the MNRE benchmarking such cost in a bid to slash down pricing as noticed in the case of solar. (MNRE, 2022)
These are essentially some of the factors that stand true for developing nations that often face resource difficulties in the adoption of renewable energy. Let us quickly analyze the natural resource frame for India- Even though India started geothermal projects among the first nations in the 1970s, the country currently has no geothermal facilities that are in operation. About 340 geothermal hot springs have been found in India according to the Geological Survey. The country's hot springs are divided into seven geothermal provinces: Himalayan, Saharan, Cambay, San-Narmada-Topi lineament belt, West Coast, Godavari, and Mahanadi. For direct heat applications, the majority of them are appropriate because of their low surface temperatures, which range from 370C to 900C. The generating of electricity is only appropriate for some. Around 10,000 MW of electricity might be produced at these locations. (Geothermal Energy | Electrical India Magazine, 2022)

Country	Installed capacity (MW)
USA	3389
Philippines	1848
Mexico	1017.4
Indonesia	1341
Italy	8755
Japan	537
New Zealand	842.6
Iceland	664.4
Costa Pica	207.1
El Salvador	204.4
Kenya	248.5
Russia	81.9
Nicaragua	149.5
Guatemala	48.0
China	27.0
Papua New Guinea	56
Turkey	166.6
Portugal	28.8
Total	**11772**

Table 1- Installed capacity of geothermal power plants in different countries (2013)
Source: (Geothermal Energy | Electrical India Magazine, 2022)

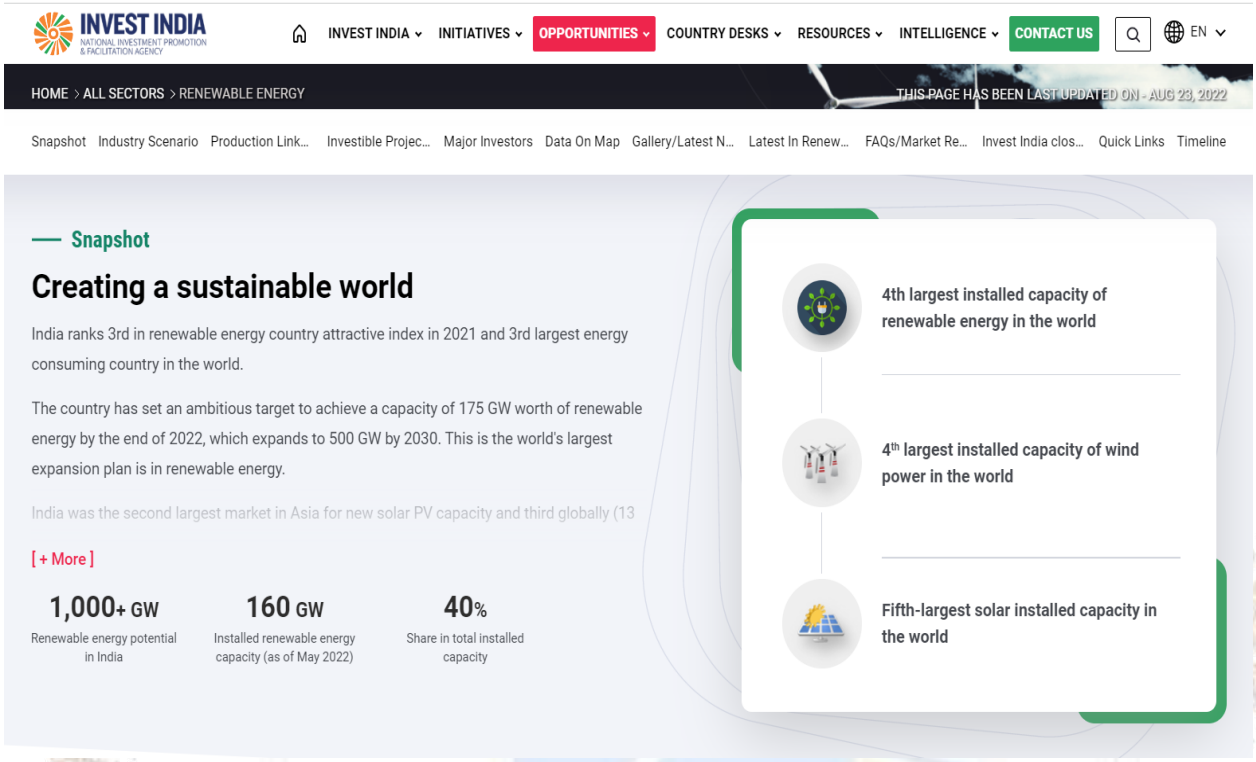
India receives enough sunlight and has a steady wind speed. As a result, there are more opportunities for solar and wind energy system expansion in the Indian context, as well as sufficient future potential for these renewable sources through "Grid Parity." These have served as a catalyst for reining the success of renewable energy in India.



Source: MNRE, 2009

The potential for solar, wind, bioenergy and small hydropower in India has been assessed by the Ministry of New and Renewable Energy (MNRE) to be 55 MW/Sq Km, 45 000 MW, 14 300 MW, and 10 000 MW, respectively.
As of December 31, 2021, the total installed capacity for renewables distributed stood as follows-
Small hydropower: 4.83 GW Large hydropower: 46.51 GW Wind power: 40.08 GW Solar power: 49.34 GW Biopower: 10.61 GW (Renewable Energy in India - Indian Power Industry Investment, 2022)
As of 2022, the MNRE has installed 191 MW, 2980 MW, 727 MW, and 1693 MW through solar, wind, bioenergy, and small hydropower, respectively, out of this potential. (Renewable energy programs in India, 2022)

Due to the infrastructural and technological upper hand, developing nations seem to be always leading the way with renewable energy. Luckily for India, it is today in a position to offer cutting-edge technology to other developing nations today thanks to a strong industrial base and the quick and effective commercialization of renewable energy technologies backed by legislative and growth-inducive institutional environment. (Renewable energy programs in India, 2022).



Source: (Renewable Energy in India - Indian Power Industry Investment, 2022)

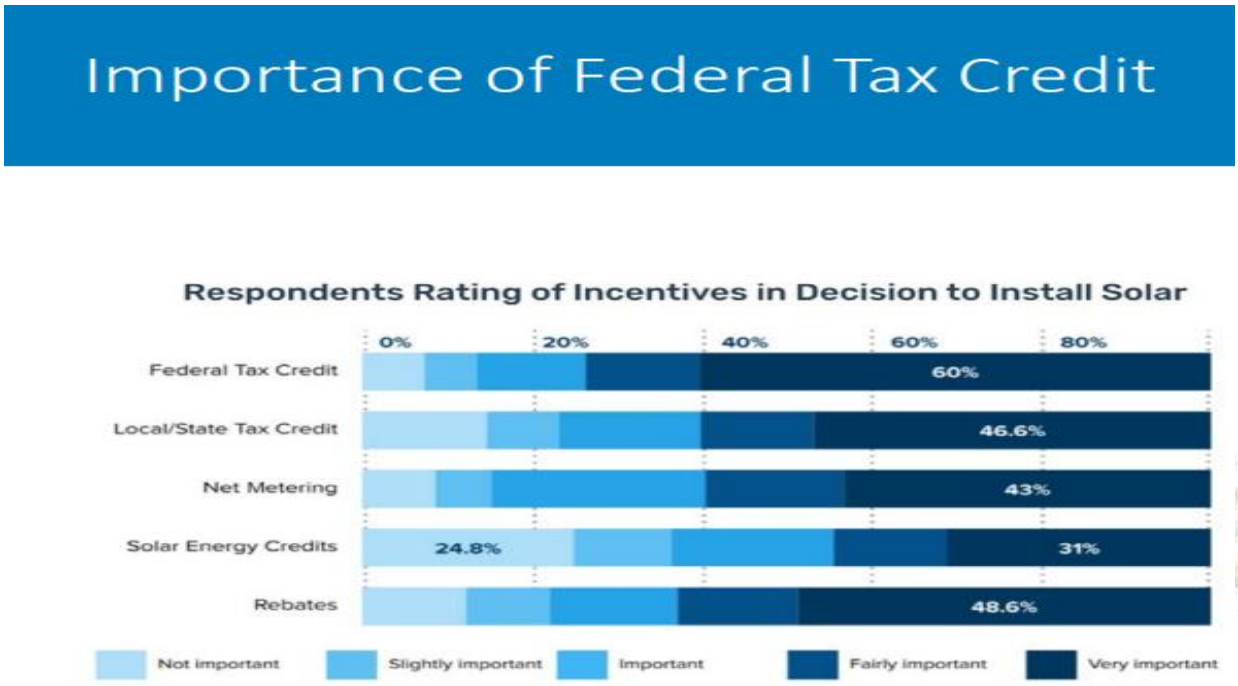
India is the third-largest energy consumer in the globe and ranks third in the attractiveness of renewable energy countries rating for 2021. The nation has set a lofty goal to generate 175 GW of renewable energy by 2020 end, which will increase to 500 GW by 2030. It cannot be emphasized enough that the ministry along with other governmental bodies and the inducive policies and subsidies have worked alongside to harness this phenomenal growth which demands the critical analysis carried out in the next segment.

Section 3

Upon review of the literature, the main obstacles to the deployment of renewable energy in developing nations are identified.

Grants and Subsidies from the Government: In most countries, the volume of government subsidies given to conventional energy is significantly more than the subsidies given to renewable energy. Therefore, in the majority of circumstances, renewable energy continues to lag. The widespread adoption of low-emission technology is being overpowered by the incentives offered by governments to produce power from fossil fuel sources. Over 80% of the total energy utilised annually around the world is derived from fossil fuels. National Geographic organization states that fossil fuels are crucial to our existence because they are both energy-dense and inexpensive to process (2022). Given that non-renewable energy has a distinct advantage (fossil, coal, natural gas), the institutional support for a growing number of renewable energy adoptions requires significant subsidies. For instance, government subsidies for mining and exploration are still provided to coal businesses in Australia and Indonesia (Dulal et al., 2013). This factor has further gained the limelight with the Global Subsidies Initiative. The **Global Subsidies Initiative** (GSI) program, launched by the **International Institute for Sustainable Development (IISD)** in 2005, is tasked with examining how subsidies—transfers of public funds to private interests- backing or thwart efforts to achieve sustainable development, taking into account the detrimental effects they may have on environmental quality, economic growth, and governance. A $21.9 billion fossil fuel subsidy is given to India. With the aid of governments and partners, GSI is aimed at eliminating subsidies that hinder sustainable development and thus pave the way for growth in the renewable energy vertical, which is increasingly important for developing countries given the rate of economic growth and their energy requirements. These interactions might put a person in a favorable or negative situation. Let us consider this in the below example:

The key incentives for the installation of PV systems and configuration are one of the factors contributing to the variance in renewable energy adoption rates by income level and nation. Let's take residential and commercial solar adoption rates as an example. In order to reimburse system owners for a certain portion of system costs in the form of tax credits, the government invests in subsidies. According to a recent study, the federal tax credit in the USA was the main motivator for households to install solar PV systems.



Source: Beacn "Residential Solar Consumer Insights." April 2021

In the USA, Section 25D is available to families, whereas Section 48 is available to companies. The tax credit is deducted from personal income for households under Section 25D. (Solar Industry Update Fall 2021, 2022)

On the other hand, the "International Institute of Sustainable Development" (IISD) and the "Council on Energy, Environment, and Water" (CEEW) collaborated on a 2022 research that indicates that during 2017, the subsidy for the renewable energy industry decreased by 59% in India. As per the CEEW report "Mapping India's Energy Policy 2022," the subsidy for the renewable energy industry was Rs 16,312 crore in 2017 but only Rs 6,767 crore in the next fiscal year (2021–2022). The report also states that non-banking finance organizations and a few private banks provided the majority of funding for clean energy projects in the nation, while public sector lenders invested more in fossil fuel-based energy projects, which is inconsistent with the country's energy ambitions (Kumar, 2022).
The debate makes it clear that a further problem limiting the implementation of renewable energy in underdeveloped countries is the availability of funding.

Economic Barriers

Finding funding for renewable energy extrapolates at rates as low as those made available for fossil fuel energy projects is extremely challenging for developers and producers. Organizations and financial tools for funding renewable project finance are scarce. This shows that the investments are viewed as being relatively hazardous, which discourages investors (Ohunakin et al., 2014).
It is only reasonable to look at the significant economic barrier stemming from the high initial cost of renewable energy developments which becomes even more of a practical pinpoint for emerging economies which has a low rate of capital formation. Renewable energy development projects have a lengthy "initial capital cost" and a "high net payback" period due to the poorer efficiency of renewable technologies, which puts CAPEX (Capital Expenditure) investors on the defensive (Ansari et al., 2016). Users and producers may both have very little capital, therefore they both need capital funding to set up a factory. The severe lending regulations that limit access to financing even when capital is available for traditional energy projects to serve to emphasize this issue even more (Suzuki, 2013). Projects frequently become unviable due to high costs of capital, a shortage of finance, and—most importantly—large payback periods (Painuly. J, 2001) and

that is a demotivator for developing countries that might seek quicker economic growth which is understandable from the political point of view. Here the interdependence of factors takes on a huge play for the adoption of renewable energy especially in the economy emerging economy perspective as discussed throughout.

Technological Barriers

Many technological obstacles prevent the widespread use of renewable energy in developing countries, such as inadequate infrastructure, inadequate operational and maintenance expertise, a lack of "Research and Development" efforts, and technical challenges like the need for energy storage and the absence of standards (Zhao et al., 2016). All of these serve as barriers to the uptake of renewable energy. Even if this technology were readily available, buying it would be exceedingly expensive. Due to the majority of renewable energy power facilities being situated in outlying areas, extra transmission lines are needed to link them to the main grid. Most current grids must be improved or modified since they are not built to integrate with renewable energy sources (Izadbakhsh et al., 2015). One of the main issues preventing the growth of renewable energy generation is grid interconnection.

The US's technological dominance in the world can be linked to lead in renewable energy space. The "Standard Energy Efficiency Data" (SEED) Platform, a web-based program developed by the "National Renewable Energy Laboratory" (NREL) and "Lawrence Berkeley National Laboratory" to handle data from large groups of buildings, was first used by Washington, D.C., in 2019. The tool, which was created in close collaboration with cities to make sure it would meet their needs, was a game-changer for the administration because it allowed them to focus on what really mattered: assisting building owners in improving their structures, while also saving valuable time and improving the accuracy of their program. Under its benchmarking rules, Washington had been monitoring the energy usage of its business buildings. However, the new rule mandated that building owners measure their energy consumption as well as reach specific goals. For instance, if they did not meet the median energy performance, they would have to make modifications to their structures or pay a fee. It is not hard to imagine such technological highs are not the characteristics of a developing economy downgrading its growth in renewable energy generation remarkably. In order to design energy networks and infrastructure and enhance the performance of existing systems, developing nations need to make more efforts in the areas of analysis, modeling, testing, and engineering assistance which again constitutes a topic for the Research & Development game of developing nations.

Inadequate Research

According to the literature survey, Research and Development (R&D) spending in poor nations is inadequate to make renewable energy sources financially competitive with fossil fuels. Governments and energy organizations are reluctant to invest in R&D since renewable energy is still in its early stages and there are significant dangers associated with this technology (Cho et al., 2013).

However, when it comes to India, in the preset of 1980s, India became the first nation in the world to establish a "Ministry of Non-Conventional Energy Resources" (Khare, Nema and Baredar, 2013).

India has a distinct ministry called the "Ministry of New and Renewable Energy" that is responsible for promoting renewable energy sources (MNES). The ministry runs a variety of programs, including those for solar energy, wind energy, bioenergy, and small hydro. Presently India has 111.39 GW of installed renewable energy capacity. According to MNRE, by the year 2020, the nation hopes to have installed enough renewable energy sources to provide 25% of its overall energy needs. (Renewable Energy Programs in India, 2022). In sum, even though India is a developing country, what is working out well for India are a centrally planned economy, strong legislature & tax reforms and most importantly growth rates and an institutional boost from time to time which is evident from the most recent statistics as India put in additional 15.5 GW of renewable energy capacity in the most recent fiscal year (2021–22) with investments of $14.5 billion (Rs11,338.8 crore). In order to decarbonize its energy sector and fulfil its pledge to become a net-zero nation by 2070, the MNRE in India strongly aims to install 450 GW of renewable energy capacity by 2030.

CONCLUSION & RECOMMENDATION

Global energy demand will keep accelerating over the coming years. Energy consumption will not increase as fast in developed nations as it will in many emerging economies, which still have a long way to go in terms of economic growth. Additionally, during the coming few decades, the world's population will continue to increase significantly. Therefore, it is reasonable to anticipate that by the turn of the era, energy consumption will have increased by a ratio of 3 to 6. As a result, both the issues with our existing energy supply and the effects of the greenhouse effect will only get worse. Additionally, fossil fuel sources will only deplete more quickly. These fossil fuels have been extensively exploited by mankind throughout the past century. The more fossil reserves are used up, the riskier, more difficult, and more expensive exploration becomes. If we continue burning fossil fuels at the current rate or even faster, all economically exploitable oil and gas reserves would have been used up by the end of the twenty-first century, leaving only coal reserves. Literature also demonstrates that as climate change persists, the overall technological potential for RE will decline. We conclude that in order to maintain environmental sustainability during the transition to RE, significant cuts in world energy use are necessary. Security of electric energy is crucial, but in energy-based economies throughout the world, renewable resources are now more appealing due to the high cost and scarcity of fossil fuels, as well as the need to minimize greenhouse gas emissions. The potential for renewable energy sources is enormous because they have the potential to, in theory, exponentially exceed global energy demand. As a result, these sources will make up a sizeable portion of the future global energy portfolio, which is largely focused on expanding its supply of renewable energy sources.

India's energy needs are rising steadily, and both commercial and renewable energy sources are being used to meet them. India's present energy needs are still primarily met by fossil fuels. It took many generations to develop natural gas, crude oil, hard coal, and lignite many thousands of years ago. They are therefore stored biomass from a long time ago since they mostly include plant and animal debris. Since there are now insufficient resources and severe pollution produced by conventional energy, it is thought that renewable energy must be employed more. In order to conclude and offer a path forward for an India focused on renewable energy in the next ten years, this study also offers a comprehensive discourse of projected energy consumption trends in India and their corresponding environmental impacts. This path forward has a lot to do with expeditious technological advancement and social acceptance.

The necessary renewable energy sources are presently accessible, and with future developments in energy technology, a renewable energy system may be constructed. For India to continue the success wheel, three key technological improvements are required: energy savings on the demand side, enhanced energy production efficiency, and the replacement of fossil fuels with a variety of renewable energy sources. Plans for the large-scale application of renewable energy must thus include strategies for incorporating renewable sources in holistic energy networks affected by energy-conserving and optimization initiatives. The development of the transportation sector will need the use of flexible energy system technologies and methods, which is of special importance.

As previously mentioned, the development of renewables is strongly tied to “market expansion”, “technological advancement”, “public policy, and other factors, after analyzing the factors and the challenges and opportunities associated with catalyzing the factors to reshape the current energy infrastructures into ones that place an increased focus on renewable energy generation, developing countries should concentrate on the following:

- “Designing mini-grid systems”
- “Setting up strict performance standards”
- “Enabling regulations”
- “Utilizing efficient business structures to accomplish efficient cost recovery and performance”

Developing countries are now being encouraged more than ever to embrace "energy planning", "policy", "investment", and "research" as well as possibilities and techniques for establishing high-performing power systems to fulfill performance criteria and achieve energy resilience.

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Appendix

1.**Primary energy** is energy in its original form, not technically processed such as crude oil, coal, uranium, solar radiation, and wind (Lund, 2014)

Table 1.3 Primary energy, final energy, and useful energy

Term	*Definition*	*Energy type or source*
Primary energy	Energy in its original form, not technically processed	Such as crude oil, coal, uranium, solar radiation, and wind
Final energy	Energy as provided to consumers	Such as natural gas, heating oil, fuel, electricity, and district heat
Useful energy	Energy as it is consumed	Such as artificial lighting, heat, drive energy for machines and vehicles

(Lund, 2014)
Lund, H., 2014. *Renewable energy systems*. 2nd ed. Waltham (MA): Elsevier, pp.8-13.

2."Political stability", "voice and accountability", "government effectiveness", "regulatory quality", "rule of law", and "control of corruption" are six measures of **institutional quality** stipulated by the World Bank.

3.The **Ministry of New and Renewable Energy** (**MNRE**) is the nodal Ministry of the Government of India for all matters relating to new and renewable energy.
4.**Gross Domestic Product (GDP):** calculates the monetary value of the final goods and services—those purchased by the consumer—produced in a nation during a specific time period (say a quarter or a year). It accounts for all the output produced inside a nation's boundaries.

5.**Gross National Product (GNP):** Gross Domestic Product plus Net Income from Foreign Investments equals Gross National Product, which is the total worth of things produced and services given by a nation over the course of a year.

6.**Per Capita Income:** The amount of money made per person in a country or region is expressed as per capita income.

7.Household income: According to the U.S. Census Bureau, household income consists of the gross cash income of every person who is 15 years of age or older and resides in the same dwelling, regardless of whether or not they are related. A household also includes a single person living alone in a place of residence.

8.**Human Development Index (HDI):** A long and healthy life, knowledge, and a good level of living are three essential aspects of human development that the Human Development Index (HDI) measures in summary form. The normalized indices for each of the three dimensions' geometric means make up the HDI.
9.**irena.org (*IRENA*)**: Established in 2005 by the International Institute for an intergovernmental body with the mission to promote collaboration, knowledge advancement, and the adoption and sustainable use of renewable energy is the International Renewable Energy Agency.

10. **The Global Subsidies Initiative (GSI)**: It was founded by the International Institute for Sustainable Development (IISD) in 2005, and focuses on examining subsidies—transfers of public funds to private interests—and how they help or thwart attempts to achieve sustainable development. Sustainable Development (IISD), the Global Subsidies Initiative (GSI) is dedicated to analyzing subsidies transfers of public money to private interests and how they support or undermine efforts to achieve sustainable development.