Chapter 2

Literature Review

This chapter represents a technical review of the preceding research work conducted in the following areas:

- *Demand Side Management*
- *Clean Development Mechanism*
- *Time of Use*
- *Solar Energy*
- *Renewable Energies Resources.*

2.1 Demand Side Management

Demand Side Management is defined as the planning, implementation, and monitoring of those utility events designed to affect customer use of electricity in ways that will yield desired changes in the utility's load shape, the time pattern, and magnitude of a utility's load. These activities might be done at the homeowner's expediency, e.g., hot water demand is low during the evening hours or during the weekday when family members are at work or school, or the utility might provide reassurance by giving a satisfactory electricity rate during the evening. Thus, with adequate capacity control, by providing appropriate, the user could meet hot water requirements by using electricity during the off-peak period, or the air conditioning controls could automatically decrease the temperature set-points to begin cooling the house with off-peak electricity shortly before occupants return home**.** There has been a growing demand for electrical energy daily worldwide. Generation needs to improve to meet the increasing demands for electricity. Increasing generation is not an easy task as it requires to set new generating units, changing transmission lines, control equipment, etc. Moreover, increased generation also causes increased environmental pollution. An alternate approach that can create a balance between demand and electricity supply without increasing generation is DSM (Mahin et al., 2019).

As presented in Figure 2.1, DSM techniques may be implemented by utilities through direct or indirect load control. In the case of direct load control, the utility shall modify the load pattern by switching-off the power supply to a specific category of customers at chosen time intervals or for specified types of electric loads (Morteza Shabanzadeh, 2013). The utility shall use a few unique methods as load period schedule, thermal energy storage, efficient end-use modern technologies, and tariff system and electrification technologies in indirect control.

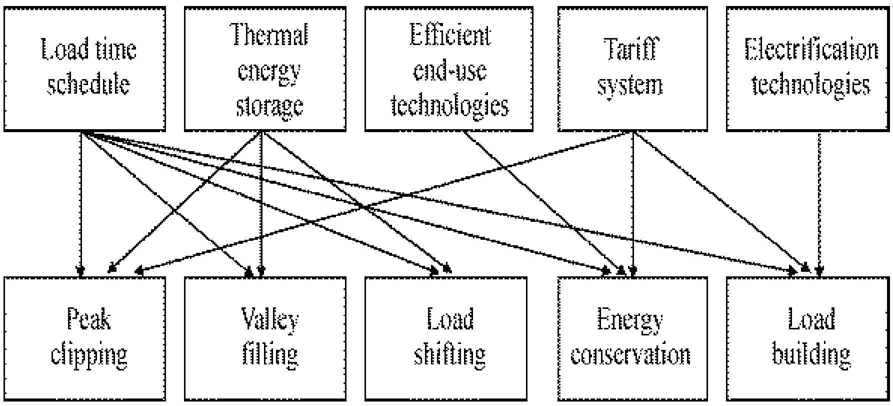

Figure 2.1. Scheme of Load Shape Objectives (Javor & Janjic, 2017)

Valley filling (Figure 2.2) is a possible DSM method applied to transform load curves to obtain greater load factors in the preset time margins. In such a manner, the utility may maximize its profit, whereas it minimizes the costs per kWh of energy. Higher demand in off-peak hours is achieved by inspiring end-customers to spend energy by paying lower tariffs or revolve the load demand distribution schedule over the day (Esther & Kumar, 2016). This will be possible if some controllable devices may operate in different time intervals during the day. The selected time interval does not apply to the customer, e.g., for a domestic or industrial customer, these might be heat boilers or storage heaters.

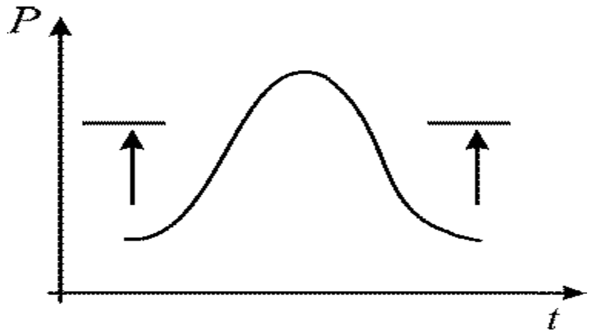

Figure 2.2 Valley Filling Technique (Janocha et al., 2016).

Load shifting (Figure 2.3) is the optimal solution from the utility companies' point of view. With this DSM method, the part of the demand is shifted from peak to off-peak hours. Customers are urged for this by the lower tariff in off-peak hours (Reddy, 1996).

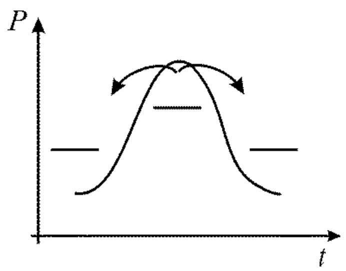

Figure 2.3. Load Shifting Method (Chauhan & Saini, 2016).

Peak clipping (Figure 2.4) also aims to reduce the demand during peak hours, especially if the installed capacity is not sufficient to cover the peak demand. This is vital in developing countries and if there is a problem with funds for the new installations and generation capacities.

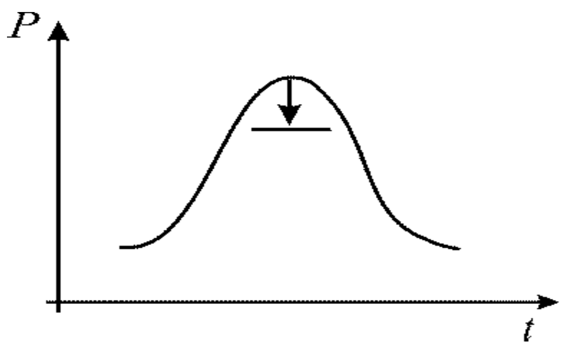

Figure 2.4. Peak Clipping Method (Javor & Janjic, 2017).

Energy conservation (Figure 2.5) is also essential in power systems, and nowadays, there are many innovations announced in this field. If it is vital to decrease the overall energy consumption, it may be achieved by using more efficient devices and appliances, which is imperative at the global level.

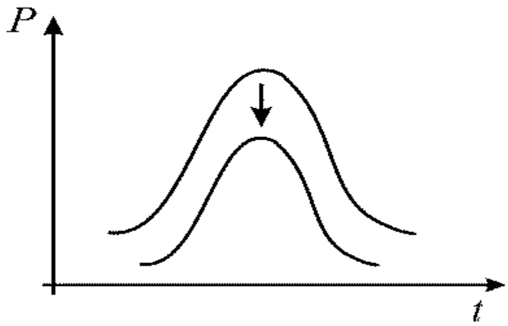

Figure 2.5. Energy Conservation Method (Khan, 2019).

Growing the overall energy consumption (Figure 2.6) is useful if some utility has the surplus capacity or available energy to sell with lower costs per kWh. This load building method is achieved with the encouragement of consumers to spend electrical energy were needed to operate the power system. There are instances of power utilities that gave customers storage heaters as great loads where this was desirable to sustain the power system capacities in the area.

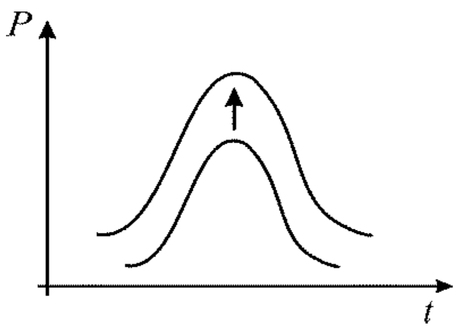

Figure 2.6. Load Building Method.

Demand Side Management is one of the real up-to-date solutions to manage electricity consumption in the developing world of insufficient electricity capacity, growing fuel costs, and environmental pollution problems. DSM offers measures to reduce consumption and expenses. To apply several DSM options and strategies, logical and optimization tools are used (Byrne et al., 2019). This also requires comprehensive information about electricity consumption dynamics, system running and planning, understanding of peak loads and their discrepancies due to environmental factors. DSM contains end-users activities to alter their consumption in a best conceivable way for both utility and the customers, but this does not necessarily lead to a decline in the total energy consumption. DSM is made through the application of activities to produce the desired daily, monthly, or seasonal load curve for utilities (Garg et al., 2014) (Reddy, 1995). DSM means averting or postponing the need to invest in new capacities, improving the power quality, ensuring organized generation, transmission, and energy distribution. For the residential customer, it means reduced bills and taking benefit of the financial incentive provided by the utility company (Khalid et al., 2019). For commerce, business, and manufacturing customers, it means lower costs included in their products price, making them more competitive on the market. DSM gives the customer a new role and choice in shifting the demands to non-peak periods to reduce electricity consumption, whereas providing lesser costs per kWh to the utility. Under DSM programs, the main activity was energy efficiency for customers (efficient heating systems, appliances, lighting, and insulation) (Morishita, Claudia; Ghisi, 2010).

The utilities need to be considered through direct or indirect load control while implementing DSM methods. In the case of direct load control, utility may alter load pattern by switching-off the power supply to a selected category of customers at a chosen time period or for specified types of electric loads (Esther & Kumar, 2016). In the case of indirect control, the company can use a few special methods as load time schedule, thermal energy storage, efficient end-use technologies, and tariff system and electrification technologies. The techniques are Valley fling, Load shifting, Peak clipping, Energy conservation, and load building technique (Esther & Kumar, 2016; Mahin et al., 2019 Martins, 1996; Reddy, 1995 Javor & Janjic 2017).

2.2 Clean Development Mechanism

Clean Development Mechanism is described as a start to developing countries off on a path towards less pollution, with industrialized countries paying for the reductions. The overall purpose of the mechanism is to enable cost-effective reductions of greenhouse gases, meanwhile contributing to sustainable development in a developing country (Tatrallyay & Stadelmann, 2013). The CDM under the Kyoto Protocol to the UNFCCC allows industrialized countries with a greenhouse gas reduction commitment to invest in emission-reducing projects in developing countries as an alternative to what is generally considered more costly emission reductions in their own countries (Sutter & Parreño, 2007; Castro, 2014). These carbon credit systems are based on the project, intending to provide financing for project activities that will cut off carbon emissions, in which renewable energy is an essential component. Due to the abundance and prevalence of resources, solar energy is widely regarded as an ideal candidate for these mechanisms (Byrne et al., 2017). However, the role of the Kyoto protocol to develop solar energy has remained comparatively small to other renewable energy projects, such as wind.

CDM projects also need a monitoring plan to collect precise emissions data. The monitoring system, which contains the basis of future verification, should assure confidence that the emission reductions and other project objectives are being achieved and should be able to monitor the risks associated with the baseline and project radiations. The monitoring plan can be established either by the project developer or by a specialized agent (Carstens et al., 2014).

The reference line and monitoring plan must be designed in accordance with a sanctioned methodology. If the project participants prefer a new methodology, it must be approved and registered by the executive board. It is mandatory for the participants to decide the length of crediting period, which may be either 10 or 7 years and which must be renewed twice for a maximum period of 21 years.

The CDM was designed with two objectives: CDM to contribute to local sustainable development in the host country. It shall assist Annex-I countries in achieving their emission reduction targets in a cost-efficient manner (Sutter & Parreño, 2007). These two CDM twin objectives are joined. The sustainable development objective emanated from the proposed Clean Development Fund (CDF) when the main driver of joint implementation remains the objective of cost-efficient emission reductions). Therefore due to the amalgam, the CDM was given a twin objective (Sutter & Parreño, 2007), "For sustainable development, it is the host party's prerogative to confirm whether a clean development mechanism project activity assists it in achieving the growth" (Sutter & Parreño, 2007). Therefore, non-Annex I countries can define the sustainable development requirements for CDM projects in their country according to their wishes. Simultaneously, many countries will not have the market capability to influence the global market value for emission reductions considerably. There is a competition among non-Annex I parties in attracting CDM investments. Therefore, it could create an incentive to set low sustainable development standards to fascinate more projects with low abatement costs. This could take the lead to a "race to the bottom" in terms of sustainable development requirements with non-Annex I parties undercutting each other to attract CDM investments, thereby undermining the sustainable development objective (Sutter & Parreño, 2007; Efficiency et al., 2007; Castro, 2014). The absence of international sustainable development standards alongside a highly competitive supply side of the CDM is likely to cause a market-off in favor of the cost-efficient emission reduction objective. Neither Annex I countries nor single non-Annex I parties have direct reasons to implement strict sustainable development criteria.

Theoretical background

The evaluation of CDM projects, based on their implementation of the two purposes of the CDM, is based on the approach Multi-Attributive Assessment of CDM (MATA-CDM) (R. Eto, A. Murata, Y. Uchiyama, 2013). The evaluation of CDM projects' contribution in sustainable development in host countries is based on the Multi-Attribute Utility Theory (MAUT). MATA-CDM aims to create a global analysis report of the sustainable development contribution of CDM projects instead of a strictly scientific evaluation of single parameters. It draws from numerous disciplines and is designed to assist decision-makers, aiming at being accurate and practical at the same time. No fixed sets of assessment criteria are there within MATA-CDM; they are to be identified in the first step. Ever since sustainable development is an overly complicated concept, a right balance between manageability and scope should be found when selecting the criteria. Consequently, evaluators and it is the task of the evaluators to be conversant with all selection requirements. The tool allows for a combination of standards from different specialties, as in this case from economics, social sciences, and natural sciences. However, charting contributions to sustainable development by selected indicators remains a simplified construction of reality, and results should be interpreted accordingly.

Climate Change Mitigation Efficiency of the CDM

Though the CDM has a series of unexpected successes, having generated more than 215 billion US$ in private investments in developing countries (Source: https://cdm.unfccc.int/). It is still unclear if it provides cheaper emission decrease without creating new significant difficulties. In distinction to an allowance system, where all actors have a limited number of allowances, the CDM is a system where one contributor has a limit on its emissions, while the other has none. Therefore, project developers need to draw a presumptuous trajectory of what the emissions would have been without the project, i.e., the baseline emission, and a counterfactual course, where emission reductions from the given CDM project are included. Therefore, Project developers also need to prove that the project would not have occurred without the CDM (Schroeder, 2007). A series of repercussions arise from this. There is a chance that a double calculating of certified emissions reductions (CERs) might happen, i.e., several CDM projects getting credits for the same emission reductions. There is also the issue of ensuring additionality, the risk for CDM projects to be credited for emission reductions that would have happened without the CDM. Since the CDM does not contribute to an actual net reduction in carbon emissions, CDM projects must reduce the emissions they are credited for. If more CERs are issued, then the actual emissions are reduced, the CDM will lead to a net increase in total carbon emissions. At the core of these problems lies the question of baseline methodology. The transnational network nature of climate change can be clearly seen in how the authority is distributed across different levels of organization actors in multi-actor and multi-level global environmental governance (UNEP Collaborating Centre on Energy and Environment, 2014). The UNFCCC demonstrates international cooperation, national governments develop and tool climate policies within national politics and institutions, European countries add an extra layer of regional and multinational governance, and Sub-national officialdoms and non-governmental organizations shape public opinion and contribute to the development of new policies. Although, the recent collapse of CER prices shows how the CDM cannot be an efficient climate change mitigation mechanism when the conditions for exchange are inadequate and there is an excessive supply of CERs compared to demand. Thus, the need for continuous improvement in the CDM. An emission cap on non-Annex I countries would avoid carbon leakage and the issue of additionality. The CDM's claim of supporting technology transfer and sustainable development while ensuring GHG reductions could thus be strengthened (Tatrallyay & Stadelmann, 2013).

The Paris Agreement

Paris Agreement, in full Paris Agreement Under the United Nations Framework Convention on Climate Change, also called Paris Climate Agreement or COP21, international treaty, named for the city of Paris, France, in which it was adopted in December 2015, which aimed to reduce the emission of gases that contribute to global warming. The Paris Agreement set out to improve upon and replace the Kyoto Protocol, an earlier international treaty designed to curb the release of greenhouse gases. It entered into force on November 4, 2016 has been signed by 195 countries and ratified by 190 as of January 2021.

From November 30 to December 11, 2015, France hosted representatives from 196 countries at the United Nations (UN) climate change conference, one of the most important and most ambitious global climate meetings ever assembled. The objective was no less than a binding and universal agreement designed to limit greenhouse gas emissions to levels that would prevent global temperatures from increasing more than 2 °C (3.6 °F) above the temperature benchmark set before the beginning of the Industrial Revolution.

The meeting was part of a process dating back to the 1992 Earth Summit in Rio de Janeiro, Brazil, when countries initially joined the international treaty called the United Nations Framework Convention on Climate Change. Seeing the need to strengthen emission reductions, in 1997, countries adopted the Kyoto Protocol. That protocol legally bound developed countries to emission reduction targets. However, the agreement was widely believed to be ineffective because the world's two top carbon dioxide-emitting countries, China, and the United States, choose not to participate. China, a developing country, was not bound by the Kyoto Protocol, and many U.S. government officials used this fact to justify U.S. nonparticipation.

At the 18th Conference of the Parties (COP18), held in Doha, Qatar, in 2012, delegates agreed to extend the Kyoto Protocol until 2020. They also reaffirmed their pledge from COP17, which had been held in Durban, South Africa, in 2011, to create a new, comprehensive, legally binding climate treaty by 2015 that would require all countries—including major carbon emitters not abiding by the Kyoto Protocol—to limit and reduce their emissions of carbon dioxide and other greenhouse gases.

In the lead-up to the Paris meeting, the UN tasked countries to submit plans detailing how they intended to reduce greenhouse gas emissions. Those plans were technically referred to as intended nationally determined contributions (INDCs). By December 10, 2015, 185 countries had submitted measures to limit or reduce their greenhouse gas emissions by 2025 or 2030. The U.S. announced in 2014 its intention to reduce its emissions 26–28 percent below 2005 levels by 2025. To help accomplish that goal, the country's Clean Power Plan was to set limits on existing and planned power plant emissions. China, the country with the largest total greenhouse gas emissions, set its target for the peaking of its carbon dioxide emissions "around 2030 and making best efforts to peak early." Chinese officials also endeavored to lower carbon dioxide emissions per unit of gross domestic product (GDP) by 60–65 percent from the 2005 level.

India's INDC noted the challenges of eradicating poverty while reducing greenhouse gas emissions. About 24 percent of the global population without access to electricity (304 million) resided in India. Nevertheless, the country planned to "reduce the emissions intensity of its GDP by 33 to 35 percent by 2030" versus the 2005 levels. The country also sought to derive about 40 percent of its electric power from renewable energy sources rather than from fossil fuels by 2030. The INDC noted that the implementation plans would not be affordable from domestic resources: it estimated that at least $2.5 trillion would be needed to accomplish climate-change actions through 2030. India would achieve that goal with the help of technology transfer (the movement of skills and equipment from more-developed countries to less-developed countries [LDCs]) and international finance, including assistance from the Green Climate Fund (a program designed to assist, through investments in low-emission technologies and climate-resilient development, populations vulnerable to the effects of climate change).

The Value of Certified Emission Reductions

There are number of factors determine the value of a CER on the market (Stiles 2005c):

- Bankability. CERs are the only carbon units that can be banked in one year and sold later. Other carbon units such as those earned in the EU ETS scheme must be used in the year they are allocated. If a company in the EU emits less carbon or GHG than they are allowed to in a specific year, they cannot hold on to their EU ETS allocation and be allowed to emit more GHG in the next year. However, CERs that are bought in one year can be kept until the next year to offset the next year's GHG emissions. The theory is therefore that CERs should have higher value than other carbon units, because they can be banked, i.e., they do not have to be redeemed immediately.
- Sustainable development. Due to the characteristics of the CDM and the requirements of a CDM project, such a project should enhance a company's social responsibility profile. The host country has issue a LoA (Letter of approve) before any CDM project can be registered. The host country's DNA must ensure that the project complies with their sustainable development targets and, as a result, might require that a portion of the proceeds from CERs be spent on social development, etc.

Delivery risk. Because CERs are still relatively new there is still a risk that a company that registers a project could eventually not implement it and therefore not earn any CERs. As a result, a company that wants to buy CERs to offset against their GHG emissions could take out an option to buy future CERs from another company that could potentially earn CERs. "This risk element is outweighing the inherent advantages to CERs as a carbon unit, resulting in CERs being traded at a discount on the carbon market. Once a spot market for CERs emerges with the issuance of the first credits of this type, this situation is expected to change to trading of spot CERs at a premium" (Stiles 2005c: 9).

2.2.1 *Carbon Emissions, Economic Growth, Energy Consumption, Trade and Urbanization in EU*

Income has a fundamental relationship with renewable energy consumption of a country, and it is worthy of considering the effects of CO_2 emissions on economic development, energy consumption, and trade. A study carried out by Adnan Kasam and Yavuz Selman Duman examines the causal relationship between energy consumption, CO_2 emission, economic development, and urbanization for a panel of new EU member countries over 1992 2010. Table 2.1 and Figure 2.7 illustrate the standard deviation (Stdev), per capita GDP, per capita carbon dioxide emissions (CO_2), per capita energy consumption (EC), trade openness (TRADE), and the share of urban population (URBAN), respectively, over different countries (Kasman & Duman, 2015).

Table 2.1: Stdev, GDP, CO2, EC, TRADE and URBAN for different countries (Kasman & Duman, 2015).

Country		CO_2	GDP	EC	TRADE	URBAN
Bulgaria	Mean	6.26	3,200	2,499	111	69
	Stdev	0.64	817	148	15	2
Croatia	Mean	4.60	8,359	1,804	89	56
	Stdev	0.62	2,212	209	10	1
Czech Republic	Mean	11.93	11,239	4,182	114	74
	Stdev	0.72	2,061	191	14	0
Estonia	Mean	12.27	7,890	3,803	149	70
	Stdev	1.12	2,645	263	12	0
Hungary	Mean	5.65	9,280	2,545	124	66
	Stdev	0.29	1,604	91	34	1
Iceland	Mean	7.36	47,490	11,518	76	92
	Stdev	0.483	6,801	3,085	11	1
Latvia	Mean	3.527	5,442	1,944	103	68
	Stdev	0.665	1,997	195	16	0
Lithuania	Mean	4.325	6,253	2,570	112	67
	Stdev	0.556	2,034	264	25	0
Macedonia	Mean	5.518	2,757	1,351	100	59
	Stdev	0.292	327	74	15	0
Malta	Mean	6.247	13,911	2,006	170	93
	Stdev	0.467	1,749	143	10	1
Poland	Mean	8.409	7,032	2,496	63	61
	Stdev	0.528	1,739	116	16	0
Romania	Mean	4.667	4,124	1,852	68	53
	Stdev	0.556	992	149	9	0
Slovak Republic	Mean	7.328	10,090	3,358	143	56
	Stdev	0.477	2,528	100	21	1
Slovenia	Mean	7.546	15,546	3,315	116	50
	Stdev	0.554	3,137	333	13	0.0
Turkey	Mean	3.363	6,351	1,194	46	65
	Stdev	0.45	922	151	6	3
Panel	Mean	6.6	10,598	3,096	106	67
	Stdev	0.158	639	150	2	1

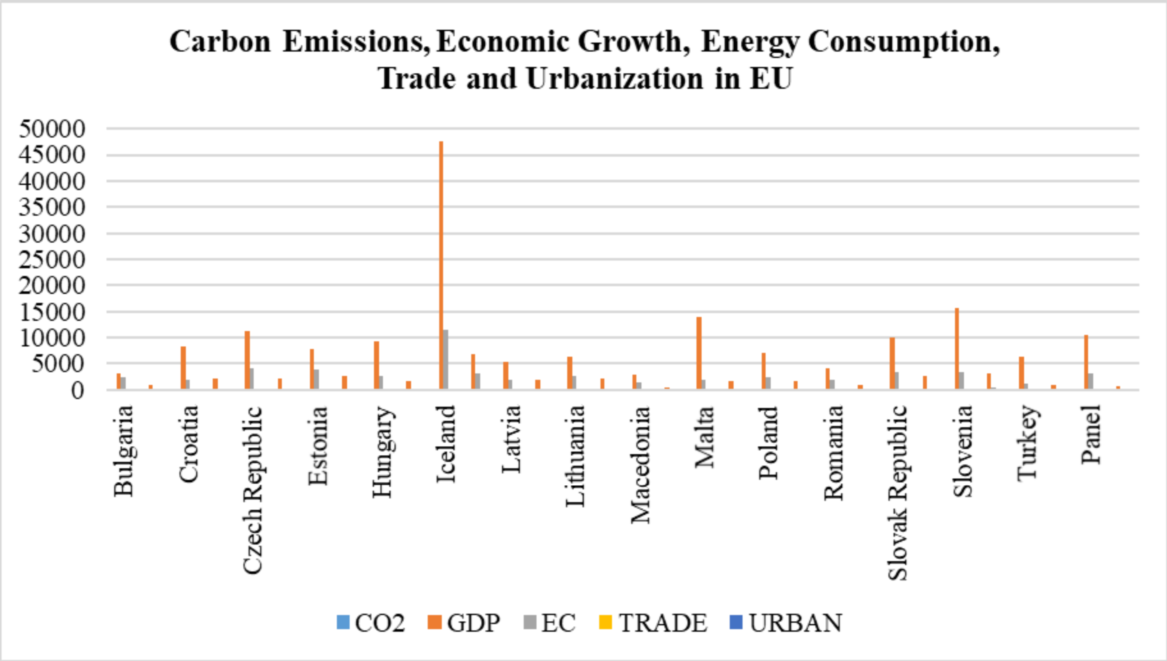

Figure 2.7 Variation of GDP, CO2, EC, TRADE and URBAN for different countries

(Kasman & Duman, 2015).

Panel integration methods, panel causality tests, and panel unit root tests are used to scrutinize this relationship. The main results achieved here are indications supporting the Environmental Kuznets Curve hypothesis, which is a hypothesized relationship between environmental quality and economic development - various indicators of environmental degradation tend to deteriorate as modern economic growth propels until average income reaches a certain fixed point over the course of development. Hence, an inverted U-shaped relationship between environment and income is observed by them (for the sampled countries). The results also seemed to indicate short-run unidirectional panel causality running from energy consumption, trade openness, and urbanization to carbon emissions and GDP to energy consumption. For the long-run causal relationship, the results point towards that estimated coefficients of lagged error correction term in CO_2 emissions, energy consumption, GDP and trade openness equations are statistically significant, implying that these 4 variables play an indispensable role in changing the process from the long-run equilibrium. This clearly shows that the cause and effects of CO_2 emissions are not exclusive but are mutually inclusive to every other cause-effect in an interlocked form. Hence, an improvement in CO_2 emissions creates a corresponding improvement in factors such as economic growth and energy consumption (Ceylan et al., 2014).

2.2.2 *Carbon Discharges in China*

Carbon emissions are an excellent way to keep the path of global warming and environmental cleanliness in general. A study done by the Chinese Academy for Environmental Planning, Beijing, China, analyzed the variation in CO_2 emissions over different cities' boundaries (Cai & Zhang, 2014). Four types of urban boundaries were discovered and defined, namely UB_1 (city administrative boundary), UB_2 (city district boundary), UB_3 (city built-up area), and UB_4 (urban proper). The case study to illustrate different performances of CO_2 emissions (Figure 2.8) with respect to these four boundaries using a 1 km grid dataset-built bottom-up by point emission sources was the city of Tianjin. From Figure 2.8, a difference a large as of 654% was observed in the CO_2 emissions between two urban boundaries. UB_1 is a widely adopted boundary, although UB_1 and UB_2 are not suitable proxies for urban boundaries in the analysis of CO_2 emissions. UB_4 is an appropriate boundary system for events like urban CO_2 emission with respect to landscape characteristics and appropriate human activities, whereas UB_3 can be an ambassador of urban sprawl or city clusters in a certain region.

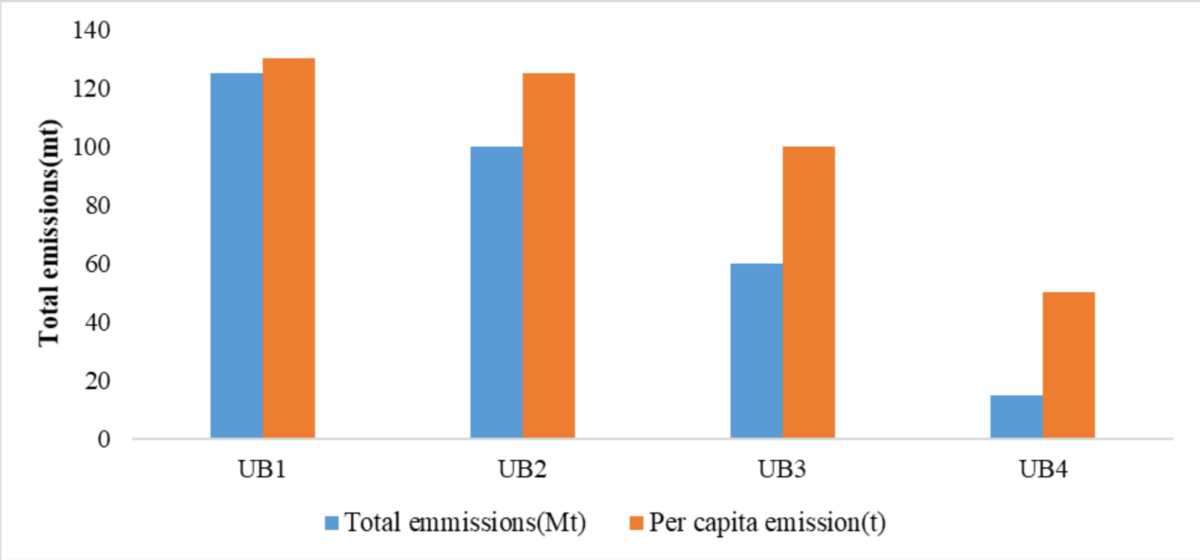

Figure 2.8: Graph comparing the difference in CO_2 emissions of different boundaries

(Cai & Zhang, 2014).

Proper policy implications for the development of urban energy management and carbon emission reduction can be derived from these results. This also illustrates that CO_2 emissions' data can be misleading if stated for a different border, and policy introduced keeping a different one in mind.

2.3 Renewable Energy in Emerging Economies

With the issue of environmental worsening and global warming at hand, many countries have started investing heavily in renewable energy sources, India included. Another study analyses the proactively accelerated adoption of renewable energy in emerging economies, namely Brazil, China, India, Indonesia, Philippines, and Turkey (Salim & Rafiq, 2012). Using full-modified ordinary least square (FMOLS), dynamic ordinary least square (DOLS), and Granger causality methods, its study revealed that, on a longer span, renewable energy consumption in Brazil, China, India, and Indonesia is mainly determined by income and pollutant emission in these countries. Whereas in the Philippines and Turkey, income alone is a sufficient metric for renewable energy consumption. Figure 2.9 shows the variation of

Renewable energy (RE), carbon emission (CO_2), output (Y), and oil prices (OP), respectively, over time in 6 countries (Salim & Rafiq, 2012). Their results suggest that the appropriateness of the efforts embarked on by emerging countries to reduce carbon intensity by increasing energy efficiency and substantially leads to the advancement of renewable in the country's overall energy mix.

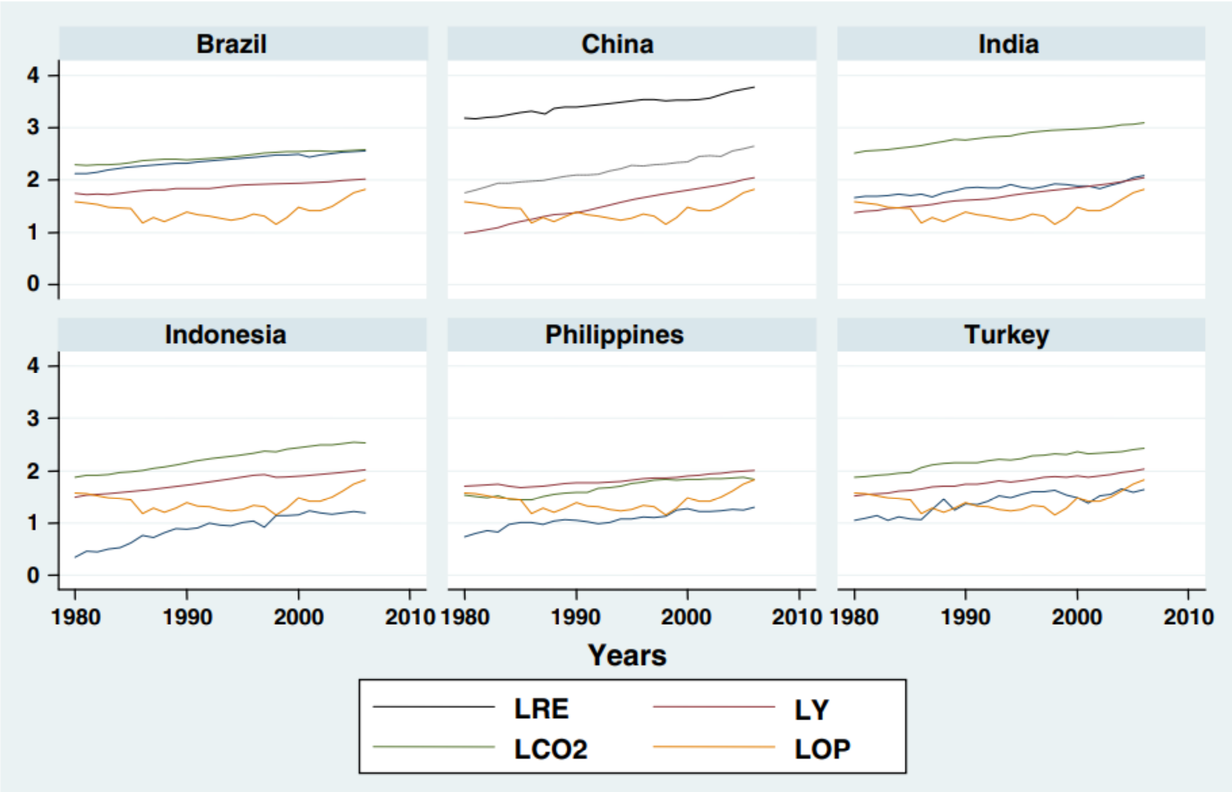

Figure 2.9: Variation of RE, CO_2, Y and OP over time in 6 countries (Salim & Rafiq, 2012).

In George E. Halkos and Eleni-Christina Gkampoura's research paper on (Usage, Potentials, and Limitations of Renewable Energy Sources) Published in June 2020, they stated Energy as vital for the satisfaction of basic human needs. It is essential for human wellbeing, everyday living, communications, and social mobility, and, in general, economic, and social development and well-being. World's energy needs have increased precipitously in the recent years and, as populations grow, combined with the economic and technological growth, they are expected to increase even more. According to the U.S. Energy Information

Administration (EIA), between 2018 and 2050, the global population is predicted to rise to approximately 9 billion by 2050, while the world energy consumption is predicted to rise by nearly 50% (EIA, 2018). Since the industrial revolution, fossil fuels remain the main source of energy, and their usage has grown to almost 10,000 million tons of oil equivalents. In 2010, fossil fuels provided about 80% of all primary energy worldwide, and they are expected to be used in the same substantial amount in the future to meet global energy needs. More specifically, fossil fuels are anticipated to constitute 78% of total energy consumption worldwide in 2040. The negative effect of fossil fuels on the environment has been known for a long time, which is a direct cause of global warming and climate change. According to the United States Environmental Protection Agency, 65% of total GHG emissions are CO_2 emissions that come from fossil fuel and industrial processes. The UNFCCC in 1992 set the foundations for the reduction of GHG emissions, stating that a reduction is essential to avoid catastrophic outcomes on the environment. In addition, the Sustainable Development Goals proposed by the United Nations in 2015 include the issue of clean energy, climate change, and greenhouse emissions. One of the main reduction measures is the limitation of fossil fuels use and the transition to renewable sources, as energy is a key factor in sustainable development. Besides, the limited sources of fossil fuels and their high costs make the shift to renewable sources more essential to reassure energy security and meet the energy demand. Renewable energy has an ordinary share of 17.5% in total final energy consumption worldwide over the period 1990–2015, and it is expected to be the fastest-growing form of energy in the future

Definition

Eleni-Christina Gkampoura's said, "Renewable energy sources (RES) or alternative energy sources are considered as the energy sources that can be renewed, produce energy over and over, and are inexhaustible. RES includes solar energy, wind energy, bioenergy, geothermal, hydropower, and ocean energy, and they can be used for power generation, transportation, domestic use, urban heating, etc."

Possibilities

Renewable energy sources have a significant number of capabilities and advantages. They can improve environmental quality since they produce little or no GHG emissions. They distribute energy equally and solve energy security and energy poverty problems. Since they can be found in almost every place on earth, they can be considered reliable energy sources compared to fossil fuels. Also, they have a low operation cost and economic benefits, and at a macroeconomic level, they support employment and stabilize energy prices. They can improve living conditions in a household and can cover most energy needs without running out. In addition, even studies have shown that they can positively impact human health because of their little GHG emissions; they do not lead to many health problems compared to fossil fuels.

Limitations

The main disadvantages of renewable energy sources include the higher initial cost (now comparatively cheaper) that can be extreme and a deterrent for users, as well as the cost of storing systems, which is also relatively high. Furthermore, renewable energy depends on weather conditions, and unpredictable weather conditions could lead to energy shortage for a long time. In addition to that, large land areas are essential to install the necessary renewable energy technology. Renewable energy sources could provide around 50% of the total energy required in the United States, but more than 17% of the land would have to be used. Despite the small hindrances, renewable energy sources are the best option to meet the world's energy demands, change the excessive use of fossil fuels, and satisfy the 7th Sustainable Development Goal (SDG) for affordable and clean energy.

2.4 Time of Use

Under ToU pricing, consumers face higher prices during peak hours and reduced prices during off-peak periods (Khalid et al., 2019). The desired behavioral response prompted by dynamic pricing may lead to unintended environmental consequences. Peak demand for summer usually happens during the afternoon, and solar power production is an important contributor to power generation. Shifting consumption to the evening or early morning hours may increase electricity generation via dirtier nonrenewable power sources. Reallocating consumption to off-peak hours may therefore offset the environmental benefits of conservation during the peak hour (Harding et al., 2019). The electricity market has an exciting feature of supply because demand must be balanced in real-time to avoid damage to the distribution grid. Large amounts of electricity are expensive to store over time. Moreover, while consumers generally pay fixed prices, production costs can vary dramatically over the course of a day. The gap between market price and varying marginal cost leads consumers to over–or under–consume electricity at different parts of the day. This consumption pattern carries high social costs, as electricity generation is costly in terms of pollution and resources (Harding et al., 2019). The introduction of Dynamic price for electricity consumers intended to equalize production costs and market prices. Effectiveness can be improved by discouraging power consumption during periods of peak demand and encouraging greater usage during off-peak periods (Harding et al., 2019). Dynamic pricing therefore incentivizes households to reduce the difference of electricity demand from hour to hour. With the introduction of smart meters dynamic pricing for electricity is now technically feasible because it allows two-way communication between utility and customers.

They examined the treatment effects of a dynamic pricing structure with a single peak price called every afternoon. Treated households are given access to the same technologies described in this paper. They find that automation (using programmable thermostats) is associated with a large reduction in the quantity of electricity demanded during peak pricing periods. Moreover, automated households display evidence of load shifting, smoothing electricity consumption over the course of the day. Load shifting is an important feature of this dataset. They concur with previous randomized control trials in that consumers are seen to respond to price incentives. They examined a small sample of electricity consumers in Anaheim, CA, during the summer of 2005 (Harding et al., 2019). Customers in both the treatment and control groups face the normal block-rate price structure. Treated customers have the opportunity during "critical peak pricing" events to earn a rebate of $0.35/kWh for reducing their electricity use compared to non-critical peak pricing days. Critical peak pricing for these consumers is associated with a reduction in consumption of about 12%. There is not a change in consumption among the treatment group on noncritical peak days. Other work on randomized control trials often features experiments with both a price component and an information component. Harding et al. used data from a 2007 trial of time of use pricing accompanied by various forms of information feedback to consumers (Harding et al., 2019). Time of use pricing is found to be associated with significant reductions in peak usage, but there is a limited response to increasing the size of the price differential during peak hours. Different information feedback systems are associated with differential responses to the TOU pricing period. The importance of information provision is highlighted in a study examining how households respond to unpredictable price events (Harding et al., 2019). Treated households are assigned to either of two groups: 'price' and 'price with in-home display'. Price events occur with varying amounts of advance notice: one day ahead or thirty minutes ahead. Households with the in-home display are found to be much more responsive to price events.

2.5 *Energy Efficient Electrical Device: Air Conditioners*

Phadke et al. have done general research on increasing the energy effectiveness of air conditioners in India and their cost-effectiveness at multiple levels, including consumers, manufacturers, and utility (Phadke et al., 2014). They found that the efficiency of ACs can be improved by over 40% cost-effectively. The total potential energy savings from Room AC efficiency improvement in India using the best available technology was found to be over 118 TWh in 2030; potential peak demand saving was found to be 60 GW by 2030. This is equivalent to avoiding 120 new coal-fired power plants of 500 MW each. They assessed that about 30% of the urban households are likely to own a room air conditioner by 2020 while 73% by 2030.

2.6 Rooftop Solar PV

The Indian electricity sector is undergoing rapid changes, among which the most important is the progress of solar power in the country. While this is helping increase competition in the sector and fulfill India's obligations on climate change, it is also throwing up many challenges like low and decreasing capacity utilization of the thermal power generating projects; this will add to the financial stress of the power sector. However, the Indian electricity sector's challenges are part of global trends, and India must prepare for it. In the recently concluded solar auctions, solar tariffs have reached a low of INR 2 per unit of power (compared to INR 6 per unit average cost of electricity supply for distribution utilities). The low cost of solar power means that it has reached grid-parity and more, which is the primary driver for its rapid growth. India currently has an installed capacity of 35 GW of solar capacity, which is about a tenth of the country's installed power generation capacity. Falling solar prices is helping the cause of open access in the power distribution sector (with consumers having a choice of electricity supplier just as in the telecom sector). Using open access, DMRC, for example, is sourcing 32% of its power requirements from the Renewable solar project in Madhya Pradesh. Open access in the power distribution sector is one of the abandoned provisions of the Electricity Act, 2003, and operationalizing it would make the power sector competitive, which, in turn, would improve the cost competitiveness of the Indian economy. One of the significant criticisms of renewable power like solar and wind is their intermittency. However, recent contracts, anchored on renewable energy, have also reached grid parity. Renew Power won the world's first tender for round-the-clock supply of green power (solar, wind, solar-storage or hydel) by quoting a tariff of INR 2.90 per unit (first year) in May 2020. Adani Green Energy has recently won the bid for firm renewable power at INR 2.96 per unit, which is far below the country's average cost of power supply. The need for cleaner power is also overdue, with six Indian cities figuring among the world's ten worst polluted. As per the State of Global Air report 2020, air pollution contributed to over 16.7 lakh deaths in India in 2019. And it is well-known that coal-based thermal power generation is a major cause of air pollution. The coming energy transition is also as per domestic plans. As per its Nationally Determined Contributions, as part of the Paris Accord, the government has pledged a decrease in the emission intensity of its GDP by 33-35% by 2030 from 2005-levels 40% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. This would clearly mean more renewables in the energy mix, pursuant to which the government had targeted a renewable capacity of 175 GW by 2022, of which 100 GW would be solar power. With an installed solar capacity of 35 GW, we are well on our path to achieve the target. However, the coming of age of solar power and open access in India would increase the power distribution sector's challenges, which is dominated by the public sector power distribution companies (discos). These discos have existing long-term power purchase agreements (PPAs) with mainly coal-based thermal power generating projects. Any decrease in thermal power demand emanating from less expensive solar power and operationalization of open access would mean more financial stress for the discos (losses for distribution utilities increased from INR 29,452 crore in 2017-18 to INR 49,623 crore in 2018-19) as they would be required to pay the fixed costs of power. The DISCOMs' financial stress would also be moved to the thermal generation projects, many of which are already stranded, queering the pitch further for banks and other lending institutions through increasing their non-performing assets (NPAs). To add to this, with solar power reaching grid parity, the capacity utilization (plant load factor) in the thermal generation is expected to fall further from the already low below-60%, making it more uncompetitive, as the fixed costs get spread over smaller volumes of power. What the Indian electricity sector is going through is in sync with worldwide trends. The International Energy Agency's World Energy Outlook observes that the world electricity sector looks set to evolve into a system with lower carbon-dioxide emissions and enhanced flexibility (IEA, 2020b). Solar output is likely to lead a surge in renewable power supply in the next decade, with renewables expected to account for 80% of global electricity generation growth. Renewables are expected to overtake coal as the primary means of producing electricity by 2025. Coal's share of global electricity generation is expected to fall to 28% in 2030, down from 37% in 2019. Given the impending changes in the electricity sector, the power distribution segment may have to plan for a future without state-run discos. In the interim, it may be prudent for the discos to sign only medium-term PPAs, if at all, as most of the power transactions move to the power exchanges. More widespread privatization of power distribution (like in Delhi) means power sector financial stress does not convert into fiscal stress. Experience has shown that the private sector engages in innovative ways to be ahead of the curve.

The Solar Energy Sources

Solar energy and other renewables are all obtained from the sun. It can be directly or indirectly converted into other forms of energy. Solar energy is beneficial and can be adopted in many applications such as electricity, evaporation, utilization in plants for growth, heating of water, and buildings (Acheampong, 2014).

The solar energy is harnessed by the utilization of a solar photovoltaic device or solar concentrating thermal technologies. The former is used to convert the energy resource into electrical energy, while the latter converts the resource into heat energy. The widespread problems associated with solar energy are the small thickness of energetic flow, the huge oscillation of radiation intensity, enormous investment costs, and the fact that solar energy cannot be easily exploited in all areas. Solar energy is still a very tiny fraction of the global world energy market due to the above reasons (Acheampong, 2014). Policies to ensure the decrease in solar PV unit costs have yielded solar energy's growth rates on the back of clean energy accepted by all and sundry. It is a well-known fact that once the solar PV device is installed, it has almost no variable costs. The fact that it is not exposed to market price fluctuations gives belief that there is no forward exchange rate risk. It is an exceptionally steadfast source of energy and should play a more effective role in meeting the world's electricity needs.

Solar energy could generate about 2.5% of the world's electricity by 2025 if properly harnessed (IEA, 2020a). It has a very fabulous potential because the energy acquired from all the world's coal reserves, oil and natural gas can be matched by just 20 days' supply of continuous sunshine. The current availability levels of the solar resource and favorable worldwide government policies such as the feed-in tariff are expected to outgrow other energy sources. Feed-in tariffs allow the solar PV module's individual owner to sell excess electricity produced to the national grid for financial returns. Alwan et al. employed a model that involved a residential area with 29 houses and investigated the reduction in operating cost, PV utilization efficiency, real power loss, and voltage fluctuation, which had a residential and commercial load (Alwan et al., 2018). They reported that the residential area's utility bill went down by 62%. The commercial load went down by 25%; the reduction in power loss in the commercial load was higher than the residential load (Byrne et al., 2017). Byrne et al. explored the economic aspect of DSM for photovoltaic in the USA and reported that the Dispatchable PV DSM systems would be cost-effective (Byrne et al., 1996). Elyas et al. examined the DSM of PV generation with technical limitations such as voltage deviations and much more, for which a clonal selection algorithm was employed (Elyas et al., 2017). They reported that the load demand and the overall cost reduced for both the consumer and the utility without violating the technical constraints they were considered. Giraud et al. performed an analysis on the performance of a 4kW wind photovoltaic system for residential purposes for a period of two years and reported that the residential storage could reduce the utility's burden during peak hours and use the stored energy during hours of low demand (Giraud & Salameh, 2001).

Arun et al. analyzed Intelligent Residential Energy Management System (IREMS). They reported that the IREMS could handle multiple loads and resulted in significant savings by maintaining the total household demand below the Maximum Demand Limit and hence reducing electricity bills for consumers (Arun & Selvan, 2018a; Arun & Selvan, 2018b). Mahin et al. deployed an intelligent residential DSM system and techniques to reduce both costs for the consumer and power losses at the manufacturing end (Mahin et al., 2019). Bayram & Koç investigated the role of DSM techniques in saving energy and integrating photovoltaic solar energy in Qatar and concluded that the adoption of large-scale photovoltaics could mitigate grid operations (Bayram & Koç, 2017). Ipkachi et al. extensively explored the effects of DSM and DRM of smart grid systems on the economy

(Ipkachi et al., 2011). Khan developed an energy model involving rooftop PV panels and Tariff of Use using a CPLEX solver and solved it by employing a mixed-integer linear program and concluded that the total electricity costs are reduced for both the consumer and the utility company (Khan, 2019). Kalair et al. investigated the DSM scheme based on the relay of voltage and frequency by employing an energy management system and reported that the model reduced greenhouse gas emissions and demonstrated 97% reliability in terms of power supply (Kalair et al., 2020). Liang et al. performed a numerical analysis on the impact of small-scale devices on the outcomes of the demand response techniques and concluded that the consumers could mitigate their savings and increase their level of comfort while following the proposed model (Liang et al., 2019).

Growth of Solar energy in India

Solar power capacity in India is now increased by 11 times in the last five years from 2.6 GW in March 2014 to 30 GW in July 2019. India's Solar capacity was 36.9 GW on 30 November 2020. In India Karnataka is the largest producer state of solar energy and in 2019 capacity was near about 7100 MW. Now India is fourth largest solar power producer in the world. Top five state for solar power production in India: Karnataka 7100MW, Telangana 5000MW, Rajasthan 4400MW, Andhra Pradesh 3470MW, Gujarat 2654MW.

Indian government has an initial target of 20GW capacity for 2022. The Jawaharlal Nehru National solar mission is also called as National Solar mission. It is one of the National missions which include (NAPCC) National Action plan on Climate change. The Ministry of power and the government of India gives 30% capital subsidy on solar project. Indian government target is to achieve 100 GW installed capacity of solar electricity by 2022. IREDA (Indian Renewable energy development agency ltd) provides financial support to specific projects to generate electricity through renewable energy (MNRE 2020).

Rooftop Solar

Indian government started promoting solar in residential rooftop sector and providing subsidy benefits to consumers, channel partner, DISCOMs, etc. It is given only to residential houses not commercial establishments or industries. The subsidy amount is up to 30kW which is 40% subsidy, 4 kW to 10 kW which is 20% subsidy. Residentials can install solar system and claim subsidy through state Discom. The residential will also get 5-year warranty from the solar company. And get priority sector loan for rooftop solar installation under home loan scheme up to 10 lakhs from Nationalized Bank.

It is estimated by 2030 the price of wind and solar will be between INR 2.3-2.6 per kilowatt hour (kWh) and INR 1.9 – 2.3 per kWh while the cost of storage will be fallen by 70 percent. Residential solar energy cost INR 5.81 to INR 7.26 per kWh on average. Commercial or utility scale solar power costs INR 4.36 to INR 5.81 per kilowatt hours. The price comprises the federal solar tax credit (ITC) and it depend on the amount of sunlight and type of Solar panel installed. Solar capacity increased in the last 5.5year from 2.6 GW to more than 34 GW.

World's largest renewable energy expansion program of renewable energy has a share of 23.39 % in the total installed generation capacity in the country i.e., 368.98 GW. Solar power Tariff reduced by 75% using plug and plays model. About 19 times higher solar pump installed between 2014-2019. Record low solar tariff INR 2.441 unit achieved in Bhadla Rajasthan (MNRE 2020).

2.6.1 *Case Study: Roof-top PV system for textile industry*

Following is a case study of a textile industry located in New Delhi. The industry has contracted a demand of 100 kVA. The total available rooftop area is 280 m^2. Hence, management has decided to install a grid-connected rooftop PV plant of 25 kWp. Solar is preferred source of energy, energy available from the solar plant is utilized first and the remaining requirement is fulfilled by grid supply. The specifications of rooftop PV system are provided in Table 2.2.

- The PV system is in operation for 360 days in a year with a capacity utilization factor (CUF) of 14.5%. Then, Unit (kWh) generation = kW output × CUF × 24hours × 360days
- The benefit is the amount which is saved by generating kWh electricity units by PV system.
- The operation, maintenance, and insurance cost are considered as 2.5% of the initial investment in the system.
- Annual saving = Annual benefit – (O&M+ Insurance) cost

Table 2.3 and Table 2.4 below as report show cost balance analysis, the total saving for rooftop PV system after nine years is INR 2019786.1, the overall connection cost of the rooftop PV system is INR 18,75,000. Hence, this rooftop PV system's settlement time for the generation of 25 kWp power is 8.5 years (Table 2.4).

A system is said to be cost-effective if the settlement time is less than the lifetime of the system. Also, the payback time should be as minimum as possible. In the case study discussed above, the settlement time is one-third of the system's lifetime, so the system is cost-effective.

Table 2.2 Rooftop solar specifications

PV Panel Specification-	
• Panel rated power. • Maximum power (Pm) • Open circuit voltage (Voc) • Maximum power voltage (Vm) • Power tolerance • Maximum power current • Solar intensity • Temperature • Dimension • Maximum system voltage (Vm)	305 Wp 305 Wp 44.9 Volt 36.6 Volt 8.73 Amp. 8.33 Amp. 1000 W/m^2 25°C (1956×992×40) mm^3 1000 Volt
Number of panels	84
Inverter rating	30 kVA
Solar PV plant capacity	25 kWp
Roof-top area	275 m^2
Annual unit generation	31700 kWh
Degradation of solar output	3% in first year & 0.7% in second year onwards
Lifetime of system	25 years
capacity utilization factor (CUF)	14.5%
Electricity price escalation	2% (per year)
Structure weight	27 kg
Overall system cost (including PV array, inverter, mounting structure, cables, metering instruments)	INR. 18,75,000

Table 2.3 Cost Benefit Analysis

	System % Output	kW output	kWh (Unit) generation	Unit cost-INR (Delhi)	Benefit (INR)	(O&M+ Insurance) Cost	Savings (INR)
1st year	100	25	31320	8	263088	46875	216213
2nd year	97	24	30380	9	260299	46875	213424
3rd year	96	24	30168	9	263647	46875	216772
4th year	96	24	29957	9	267038	46875	220163
5th year	95	24	29747	9	270471	46875	223596
6th year	94	24	29539	9	273948	46875	227073
7th year	94	23	29332	9	277472	46875	230597
8th year	93	23	29127	10	281042	46875	234167
9th year	92	23	28923	10	284656	46875	237781
10th year	92	23	28720	10	288315	46875	241440
11th year	91	23	28519	10	292026	46875	245151
12th year	90	23	28320	10	295779	46875	248904
13th year	90	22	28121	11	299583	46875	252708
14th year	89	22	27925	11	303437	46875	256562
15th year	89	22	27729	11	307340	46875	260465
16th year	88	22	27535	11	311291	46875	264416
17th year	87	22	27342	12	315292	46875	268417
18th year	87	22	27151	12	319347	46875	272472
19th year	86	22	26961	12	323457	46875	276582
20th year	85	21	26772	12	327615	46875	280740
21st year	85	21	26585	12	331829	46875	284954
22nd year	84	21	26398	13	336093	46875	289218
23rd year	84	21	26214	13	340416	46875	293541
24th year	83	21	26030	13	344797	46875	297922
25th year	83	21	25848	14	349230	46875	302355

Table 2.4. Saving and Payback calculation

Saving after 1 year	Saving after 2 years	Saving after 3 years	Saving after 4 years	Saving after 5 years	Saving after 6 years	Saving after 7 years	Saving after 8 years	Saving after 9 years
216213	216213 + 213424.27	216213 + 213424.27 + 216771.72	216213 + 213424.27 + 216771.72 + 220162.90	216213 + 213424.27 + 216771.72 + 220162.90 + 223595.67	216213 + 213424.27 + 216771.72 + 220162.90 + 223595.67 + 227073.45	216213 + 213424.27 + 216771.72 + 220162.90 + 223595.67 + 227073.45 + 230596.98	216213 + 213424.27 + 216771.72 + 220162.90 + 223595.67 + 227073.45 + 230596.98 + 234166.97	216213 + 213424.27 + 216771.72 + 220162.90 + 223595.67 + 227073.45 + 230596.98 + 234166.97 + 237781.1
INR 216213	**INR 429637.27**	**INR 646408.98**	**INR 866571.88**	**INR 1090167.55**	**INR 1317241**	**INR 1547838**	**INR 1782005**	**INR 2019786.1**

2.7. Agricultural Energy Consumption in Turkey

Before leading any study, it is important to look at related studies that have previously been done in the field. Let us have a look at few studies previously done in the fields of Agricultural energy consumption, CO_2 emission tracking, and related fields. Agricultural productivity very much depends on what cost the energy is available for cultivation. Therefore, an important step in energy planning and policy development in agriculture is the prior knowledge of energy consumption. Zeynep Ceylan did a study, Industrial engineering

Department, Samsun University, Turkey, evaluates the use of MLR (multiple linear regression) and machine learning tools such as support vector regression (SVR) and GPR (Gaussian process regression) for the forecasting of agricultural energy consumption in Turkey (Ceylan, 2020).

Indicators like agricultural value added, total arable land, gross domestic product share of agriculture etc., were employed as input parameters for the model. For the preparation and testing of these models, historical data of about 28 years was used. The outcomes, as offered in Figure 2.10 and Figure 2.11, showed that BGPR (Bayesian optimized GPR) model with exponential kernel function shows a superior prediction capability over MLR and Bayesian optimized SVR model. Overall, the study was successful in appraising agricultural energy consumption in Turkey with accuracy using BGPR model. This indicates that a lot of work goes into expecting agricultural energy consumption of a country.

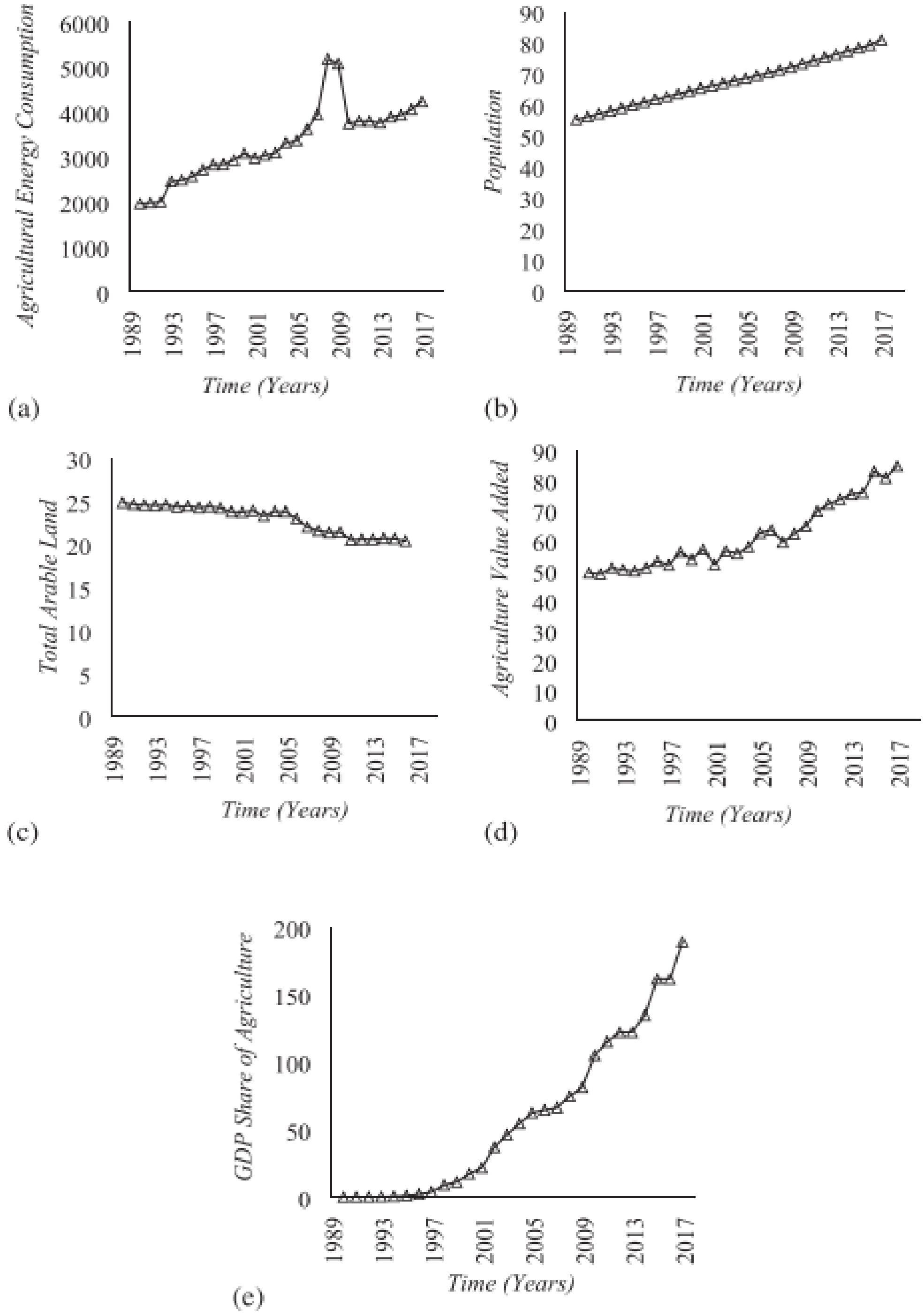

Figure 2.10: Trends of (a) agricultural energy consumption, (b) total population, (c) total arable land, (d) agricultural value added, (e) GDP share of agriculture for the period 1990-2017. (Ceylan, 2020)

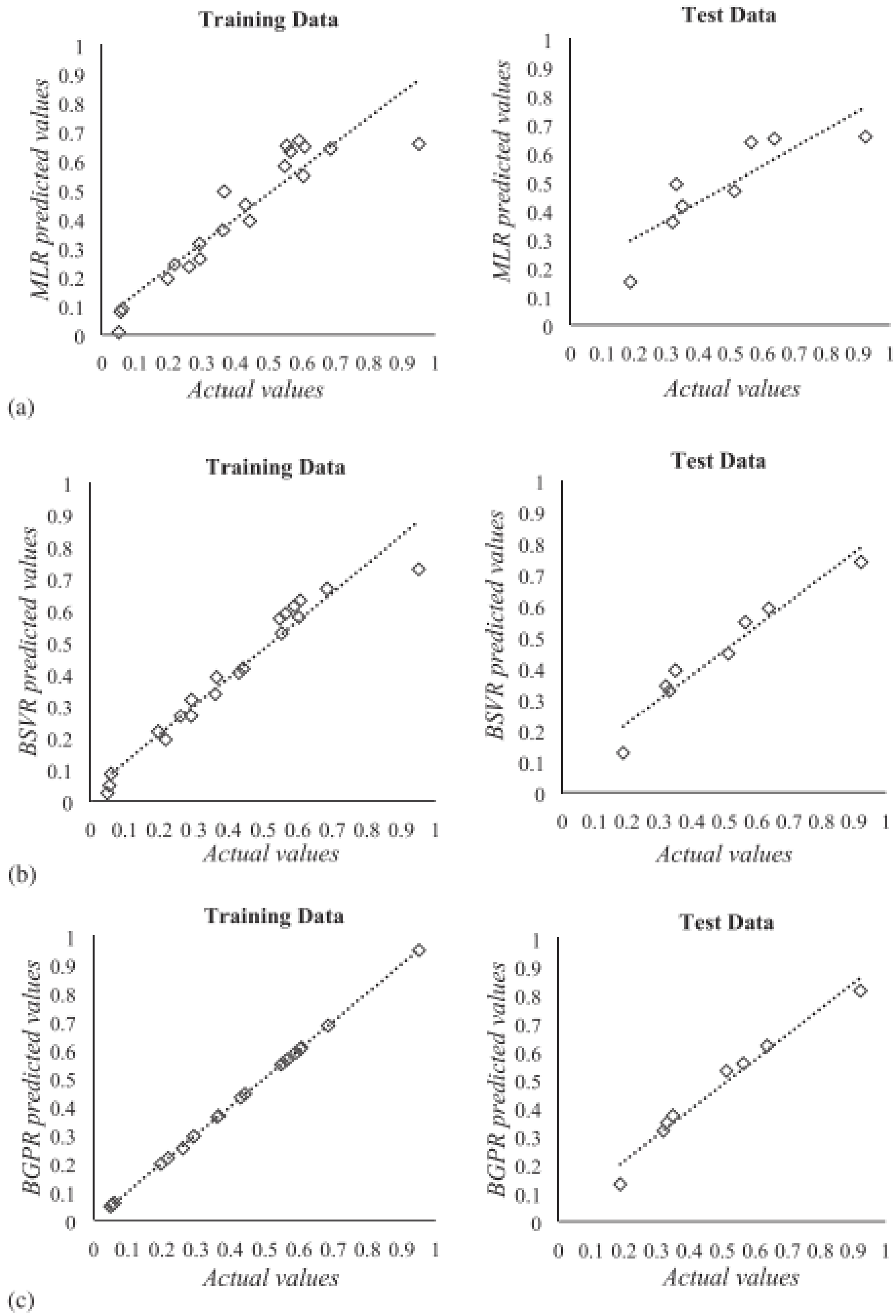

Figure 2.11: Graphical representation of normalized predicted and actual AEC value by (a) MLR, (b) BSVR, (c) BGPR models (Ceylan, 2020)

2.8. Agricultural Economic growth and energy consumption in India

Some of these studies are done in countries different than our own socially, demographically, and economically. While these studies are critical to get an idea on the higher scope of interconnection of economics, renewable energy, and per capital income, it would be suitable to get comparable data within our country. As a matter of fact, it has already been done, and very recently so. A study done by Krishna Murthy et al. published as recently as on 18th August 2020 empirically tests the relationship between agricultural economic growth and India's energy consumption (Inumula et al., 2020).

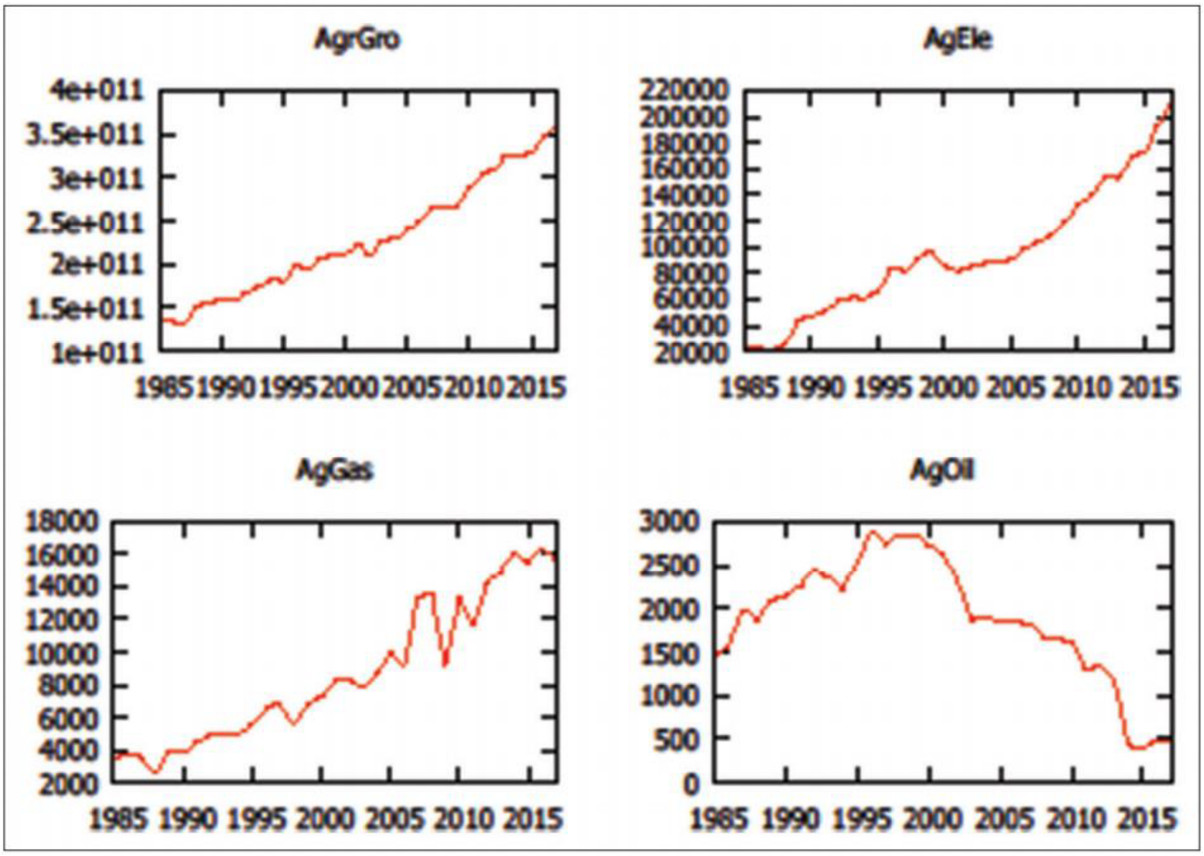

Figure 2.12: Perspective on the usage of AgEle, AgrGo, AgGas and AgOil over the years

(Inumula et al., 2020)

The study is done for a period of 1985-2017 on four economic indicators, namely agricultural value-added as an alternate favoring fiscal development of agriculture (AgrGo), energy spending represented by agricultural electricity consumption (GWh) (AgEle), agricultural gas consumption (AgGas) and agricultural oil consumption (AgOil) in India. The study variables are accessed for stationary using the Augmented Dickey-Fuller tests, and after confirming the same order of integration, the Johansen's integration test is exercised to discover the extended association amid agriculture growth and energy consumption. The test confirms the long-run balance between energy consumption and agricultural economic growth in India (see Figure 2.12). The short-run interactions are tested using the Virtual Connect Enterprise Manager methodology. Finally, the impulse responses are studied for the forecast horizon of ten years to assess India's performance of agricultural growth energy consumption by imposing one typical deviation shock to the independent variables. Overall, they exhibited a system for determining policies suggesting various parameters that would help the country in terms of agricultural development and economic growth.

2.9 Research Gap Identified:

The main finding of the literature review discloses the following gaps:

- Although there is extensive literature on DSM, only few case studies are obtainable in developing countries, mainly in the Indian context with a specific region.
- For effective DSM implementation in India, there is a need to evaluate its potential and possibility.
- Also, very few studies exist that correlate individual utility measures with DSM techniques, but no single attempt has been made to correlate CDM with all the DSM's utility measures.
- Positive DSM implementation depends on its varying implications in effectiveness, cost, feasibility, efficiency, and stakeholder approval would also help in CDM approach. This imposes a serious analysis of DSM implementation strategies from a precise stakeholder point of view.