Distributed Solar Photovoltaic Electricity Market Demand Analysis based on renewable distributed generation

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ABSTRACT
Distributed Solar photovoltaic (DSPV) power has become a popular industry and grow rapidly in worldwide and increase global economy rapidly. The need of generating renewable energy has come to be recognized internationally as a result of continuing power and energy shortages and environmental destruction. Energy and power demand and availability are in an ever-more-pronounced state of conflict as national economy expands and its energy needs rise. Through the detailed progression of power and energy market transformations, nations wind power and energy developments may extremely contribute in power and energy market communications. This research objectives at the truncated marketization of national distributed solar photovoltaic business, sleeve community facilities, and undeveloped corporate representations. Grounded on the life cycle concept, this research splits the life cycle of distributed power and energy foundations. Permitting to the difficulties in separately period and mutual with the practise of value-added facilities, the spreading is recommended. In this research, the advanced non cooperative game technique is created as well as the price structure of a dual solar photovoltaic value-added service, which contains 3 main campaign respondents about just the photovoltaic vendor, power System Corporation, and solar photovoltaic value-added users as the test subjects, is presented. The photovoltaic facility's current state is also being researched and evaluated. This research may enhance market facility competences, progress nations distributed solar photovoltaic arcade appliance, and upturn the speculation interest of arcade objects.
Keywords: Life cycle, Distributed Solar photovoltaic (DSPV), Stackelberg game

Introduction

In this section, Distributed Solar photovoltaic (DSPV) has introduced in aspect of business models.

The growth of distributed solar power production based on building roofs has been a hot topic in recent years as distributed photovoltaic energy generation in the globe has grown quickly. The internal operation of the grid firm is split between controlled and non-regulated enterprises as the selling side eventually liberalises. It is feasible for grid businesses to enhance the competitiveness of non-regulated business categories by providing high-quality value-added solutions. Value-added solutions are primarily a type of service rather than a tangible good. They can indeed be priced purely using the "cost and income" principle. Particularly, PV value-added solutions have game-like qualities and must take into account the variables that connect with each commercial entity [1]. This emphasis's the necessity of national actively developing renewable energy. The market for renewable energy is primarily driven by strong government guarantees, technical advancement, and understanding of carbon dioxide emissions control. This has accelerated the growth of renewable energy sources in China. The electricity generation of renewable energy reached 750 GW at the end of 2020, making up 39% of the country's combined capacity for energy, according to China's Renewable Energies Development Assessment (2018). Meanwhile, despite the quick development of renewable energy, China's renewable power business continues to confront a number of challenges, including a shortage of technological R&D

capabilities, challenges with funding, and high costs. These barriers impede the expansion of renewable energy sources and the advancement of industrial competence [2]. The profitability and dependability of the distribution system will be significantly impacted by the output of photovoltaic generation systems, which is rapidly influenced by surrounding conditions. This paper discusses the impact on distributed generation reliability when dispersed photovoltaic energy, in-depth the transformation in distribution system output power after dispersed photovoltaic generator, and analyses the control scheme of photovoltaic power converter in order to address the issue of voltage outpacing limits caused by decentralised photovoltaic direct connections to active distribution networks. Moreover, a numerical solution for the integration of solar energy into distribution systems has been developed, which investigates how voltage varies with respect to path length, power load, and conductors bridge area following diffused photovoltaic availability [3]. Also after more than a decade of research, the area of business models and commercial model development investigations is still characterized by a notable absence of continuous theorizing and an opportunistic appropriation of more or less comparable concepts from neighbouring fields in the lieu of comprehensive theory. We contend that the complete absence of cumulativeness is caused by a lack of due to a significant (i.e., BM and BMI are rarely characterised with great precision) and a lack of definitional contract, which in recent reports have suggested that the fundamental constructs are not segmenting markets in a way that facilitates the development of theories and empirical research. The fact that the BM and BMI concepts are utilised in several interpretive settings relates to the absence of progress on all these issues [4]. The creation and usage of renewable radiation is now regarded as a desirable renewable energy everywhere. With over 100 nations using solar photovoltaic (PV) energy, it is the third most significant renewable source of energy in terms of capacity installed worldwide, after wind and hydroelectric. Global solar PV power has grown rapidly since 2010, with an annual average growth rate of 41%. China's solar photovoltaic industry has had remarkable growth in recent years and is now a critical growing sector with advantages over competitors globally. China, a pioneer in the solar photovoltaic sector, will have installed 167 GW of solar electricity on rooftops by 2020, using a minimal amount of land. In China, there were around 50 GW of DSPV power installations [5]. The growing importance of income is taken into account when calculating electricity consumption dependent on the commodities demanded under the scenarios of business as normal, underpinning city, and inter structure. According to the findings, the urban structure affects people's patterns of consumption and electricity use. In the Regional Core City situation and the Number of co design situation, there is an increase in the number of non-mobility items and journeys on public transportation. When compared to polycentric urban structures, spatial patterns urban frameworks, as depicted in the Central Core City scenario, have a less impact on energy consumption. Based on low energy usage, the data imply that the multi-pole urban form is a superior option for dense growth [6]. There is a broad array of study on how urban buildings affect energy use, as well as potential to minimize the energy use from the perspective of constrained expansion. Two main strands of research might be generally categorised. The first research stream compares the energy consumed by different urban structures at the local and regional levels in order to examine the link between compressed urban forms and energy consumption. The majority of them concentrate on energy usage in the transportation industry [7]. By taking into account social and economic issues, solid recommendations may be derived from model numerical simulations. The majority of research, however, concentrate on family energy usage in the residence and transport industries (interior heating and cooling, appliances and lights, water heating, and personal vehicles). Rarely is energy addressed for governmental and commercial operations. Because they contribute significantly to overall energy usage, it is actually crucial to take into account energy for public and private services [8]. In general, the following three major issues raised in the discourses are frequently ignored or treated separately: I the impact of socioeconomic and economic factors on energy use; (ii) the significance of examining citizen behaviours at the precision level in various urban structures; and (iii) the significance of taking into account all energy use that is related to residents' day-to-day lives, including energy use in transportation, residential, commercial, and service sectors. It is essential to bring these issues to the attention of research scientists and to offer local governments and policy maker’s helpful guidance that is tailored to their specific planning circumstances. This might result in effective policy creation for compact growth and considerable drops in the city's overall energy usage [9]. Even though these experiments looked at the connection between urban form considerations and electricity use, some of them increasingly depended on merge statistics of fuel or power generation, which may not adequately resolve concerns that are specific to a given nation or city, like varied socioeconomic developmental stage. Academic studies examining the relationships involving urban architecture and energy use have produced conflicting results. Depending on the technique applied, the amount of available data, and the geographic context, different findings are achieved [10].

Related Works

In this section, various authors’ PV based business model research articles are analysed.

Sampaio et al. [11] has proposed successful removal of dangerous elements like mercury (throughaccumulation) and arsenic, as well as the gathering and reuse of vital raw resources like aluminium and glass, depend on the proper end-of-life treatment of PV pollution (from thin-film modules). Increasing PV garbage quantities also provide a chance to introduce new value-added activities to the PV value chain and a path to attaining combined environmentally and socioeconomic advantages for a range of stakeholders. The majority of downstream papers concentrated on recycling PV panels without mentioning additional circular solutions like PV refurbishment or repurposing.According to Zhai et al. [12], the PV sector may make a difference by deciding on a financial model that is tax-based. Since they could utilise the equivalent tax initial investment to construct the PV precision, this is particularly true for new solar businesses that sell PV electricity as a commodity. The PV business may increase profits by selling PV power while maintaining control of tax payments, as is the situation in the US right now. According to Chi et al. [13], preparing a business plan can aid in the advancement of decentralized solar PV. They think the greatest approach to boost the Chinese PV sector is through innovations in business models. In China, the integrated solar PV revenue model is currently being investigated. An extensive investigation is required for a company model that is more focused on the market. Bao et al. [14] proposes strategies for China to benefit from the powerful economic strategies of solar PV towns by comparing the U.S. and Chinese dispersed marketplaces. The connections between businesses and their users would inevitably be impacted when enterprises change their responsibilities in their economic models, claim Sauter and Watson et al. [15] in a research on the participants of PV energy generation. Some conventional providers employ consciousness.

Users are not the main players in a paradigm that is managed by a firm; instead, they appear to be passive. If the model is the population paradigm, individuals can take control and choose how the society micro-network is created. The marketing strategy selected for the Southern California region in the US is a 3rd Photovoltaic power approach, claim Miller et al. [16]. In this arrangement, PV businesses run and own the PV systems and make money by licensing or marketing PV technology or PV electricity. By deploying surveillance systems, PV enterprises that provide solutions to third parties can lower upfront costs and mitigate technical hazards. The research also revealed that smaller demographics with lesser income and educational levels like this company strategy. According to Zhang [17], the State's assistance has accelerated the development of decentralized energy development. The business strategy is still in its early stages, and if incentives continue to decline its growth may become more precarious. As of the now, China lacks a sizable decentralized energy sector. Currently, a mature company model demands new thoughts on many different levels. The future development and modernization of China's energy producers will centre on integrated renewable energy products.Szabó et al. [18] utilised BMC to examine three different types of models for PV internationally in terms of business model design. They demonstrated where and to what degree these economic models may get over implementation restrictions for energy systems. Timilsina et al [21] analysis of PV business strategies revealed that Photovoltaic system possesses revolutionary traits. This trait may be used to build a business model that relies on innovation as its main driver and then reinvent that business strategy. BMC was used by Gabriel and Kirkwood [22] to investigate the variables that might affect the decision of business models for renewable energy enterprises. These also looked at geographical variations and how they affected the different business strategies used.

Objective

In this research, a technique for micro-level power and energy assessment of the transportation, residential, and commercial sectors in nation is presented. The research primary goals are to: I describe the method of calculating participant energy usage under three distinct types of urban structures while taking into account the impact of socioeconomic and economic factors; (ii) look into the micro-level impact of urban structures on occupant behaviour patterns; and (iii) summarize the main findings from energy assessment and pattern analysis that could be used to support policy decisions and urban planning.

Business Models

The business environment is shifting quickly because to the introduction of the Internet and computer systems, which makes it more unpredictable for businesses. As a result, business practices are now highly valued by business people. Economic models continue to receive little attention from scholars, nevertheless. In educational areas, there is presently no agreement about the definition, composition, and characteristics of the marketing strategy. Joseph A. Schumpeter provided the first theoretical basis for business models when he said in 1939: "What truly counts is the challenge from new enterprises, new technology, and new access to raw materials, and innovative business models." According to Peter Drucker, a successful business model should respond to four fundamental concerns, such as "Who are the consumers?" and "What is useful to people?" and “How is it possible to offer such value at a reasonable price? Both of these experts' interpretations of business strategies serve as a solid theoretical framework for later research. Company models, revenue models, business plans, economic models, and operational philosophies are all phrases that are sometimes used interchangeably. A business model as a narrative explaining how a company operates and claimed that developing a compelling narrative is essential to success. The claim made by Magritte, nevertheless, appears overly straightforward. A marketing strategy is the logic of a commercial business or profit generating, according to several scholars. SayanChatterjee, for instance, contended that the marketing strategy depicts the distribution (active processes) of firms (services) and their expenditures (materials), based on the logic that underpins the profitability of the defined organizations. According to Teece, the core of a marketing strategy is an idea, a mechanism for companies to provide value to consumers, encourage them to make purchases, and ultimately make money. This represents management presumptions on what clients demand, how to fulfil those needs, and how to make money. The logic behind how an organization generates, delivers, and collects value is described by its business model. This final description has been included in the research since it works well with the economics of renewable energy.

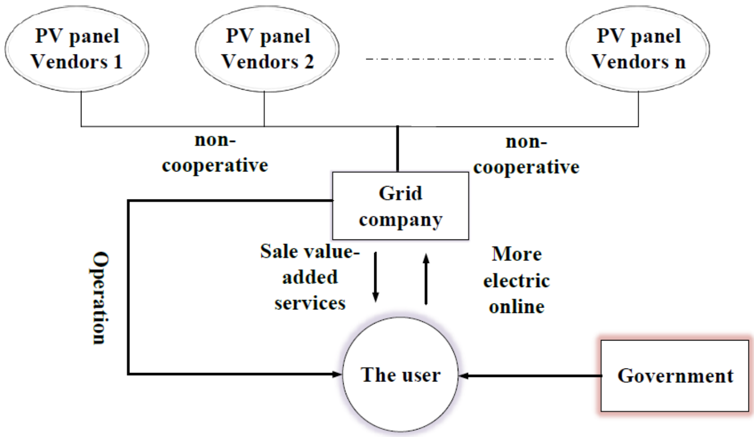

Figure 1: Distributed solar photovoltaic market value added facility scheme

Grid corporations, PV value-added service users, PV infrastructure providers, and governmental entities are stakeholders in value-added operations. Figure 1 depicts models and stakeholders in value-added business.

Vendors of PV instrumentation: Supplying Photovoltaic panels to grid utilities in exchange for a certain sum of money.

Grid Corporation: Offer all PV value-added continuous support, comprising implementation, administration, and servicing, to customers so that clients may be charged appropriately. The grid firm buys excess power from customers at the same time and the annual revenue is determined by the sale of real worth services less the cost of buying electrical from the generated energy.

Users: After paying for these services, you can sell excess power to the grid to make money in addition to saving on the cost of buying power.

Administration: Acting as a mixer of value-added solutions, it offers both financial and policy cooperation for the complete package to enhance sustainability and raise tax revenue. According to the principles of behavioural economics, the goal of the overall value-added service design is to maximise economic advantages and lower operational expenses. Minimizing network operating costs for any uncertainty in the systems is the competition's ultimate objective. As a result, the issue of maximising income progress may likewise be turned into the issue of participant-based optimum pricing. In order to resolve the issue, the Non - cooperative game is employed.

Study description

Two concepts of value-added services are put up and contrasted to illustrate how their variations in financial benefits are based on the oratorical assessment of the aforementioned game theoretical model. Henan is chosen in this instance as the geographic area for the case study examination. Henan has some applicability since it is classified as being in the third level of solar sunlight, or the area in which the quantity of sunlight is moderate. Analysis of the photovoltaic panel selling seller layered game model:

This study begins by analysing the cost of each layer of the game theory and then uses equation 1 to get the yearly electricity production in Henan. Statistics show that Henan receives around 5850 MJ/m2 of radiation annually and that there are between 1000 to 1500 hours of sunlight per year. There are 1100 hours of sunlight every year. The link between the yearly light hours mentioned in the table below and the number of hours of solar panels operating at maximum capacity reveals that the full-scale power generation time in Henan, China, is Ts=1000 hours when fixed brackets are taken into account.

It is sufficient to establish a 300 kW solar power generating system for the 4000 square metre plant to serve the basic park customers, thus set P=300. The photovoltaic committee's characteristics reveal that each one's total power output is 300W, while this system's average voltage output is set at 150W. Therefore, 3000 photovoltaic cells may be installed at the business.

$$Q = T_S \cdot P \cdot \eta \cdot (1-D)^{n-1} \quad (1)$$

Market Analysis

Distributors of solar panels: Offer a range of PV solar types to grid providers.

• Customers of the plant who acquire PV value-added services that are supplied by the grid are referred to as photoelectric value-added service customers.

• Grid businesses, or suppliers of photovoltaic value-added solutions, provide clients a broad range of services.

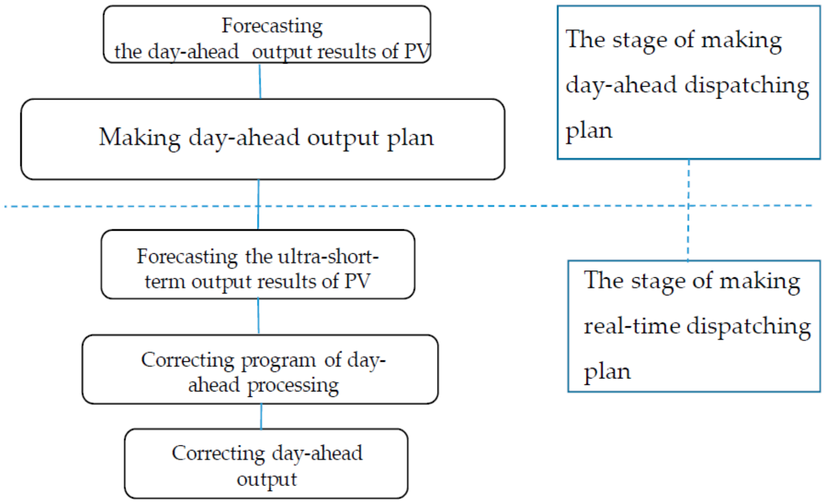

Figure 2: Flow chart of distributed photovoltaic

Because solar energy is abundant and environmentally friendly, networked photovoltaic systems may optimize the resource value of solar energy in their use. However, a decentralized photovoltaic system's stability faces a significant threat from the unpredictability and volatility of the sun. As a result, we should actively address cost management, energy efficiency, and pollution reduction, as well as optimise generation scheduling to increase the efficiency of energy conversion. In this research, a two-stage distributed photovoltaic scheduling efficiency model is suggested while accounting for energy, economy, and environmental concerns. Day-ahead forecasting and real-time sending are the two stages that the model separates the dispatching software into. Generation planning is handled via day-ahead dispatching. The following interval's operating mode is corrected by real-time dispatching, and a day's worth of production is planned based on foretasted outcomes. Figure 2 displays the full dispatching procedure. Optimizing two-stage forecasting will lessen the impact of solar energy uncertainties and decrease the demand for operational reserve in distributed photovoltaic systems, improving their conversion efficiency in terms of cost and ecological sustainability.

Demand response describes how electricity consumers act in order to alter their usual patterns of consumption in response to price signals or incentive structures in the market. Whether electricity consumers respond to the plans of power usage and demand response mechanisms is a crucial requirement for its execution. Users will use less power during peak hours. Reduced power prices and shorter electricity tariff periods are intended to assist electricity customers financially. The time-of-use energy pricing and the economic demand response based on incentive are the two demand-side response measures that are chosen in this research. Economic load forecasting is the practice of the power provider rewarding customers who actively reduce their load as a kind of encouragement. Demand response may be used to estimate the number of pre-agreed lowered loads and specify disincentives for failing to respond because of the uncertainty of the implementing preventive amount of concentrated photovoltaic, which allows the energy price to be managed and kept at the usual level.

Channels

The conventional channels used by energy service providers to sell their goods and services include salespeople, advertising, housing fairs, house displays, ground promotions, and conference marketing. Salespeople may speak with consumers directly to learn more about their wants and provide better information about their goods and services. Customers' comprehension of DSPV power may be improved through regular housing fairs, home displays, ground promotions, and conference marketing in neighbourhoods or private businesses. This can lower awareness barriers and increase the want to buy. Additionally, these businesses will advertise on social media platforms like WeChat and search engines as well as businesses' or niche e-commerce websites (taopv.cn). Under the host-owned model, a strong customer connection is important for lowering obstacles to knowledge about renewable energy solutions. Direct touch with consumers through personal channels is very important to many energy service firms. Before making a purchase, salespeople frequently speak with customers on the phone to learn more about their preferences, offer guidance, ensure that they fully understand DSPV power projects, and assess the conditions of the roof's resources, such as the amount of rooftop space available and the lighting levels. The host-owned model frequently possesses the characteristics of local absorption, decentralisation, and downsizing. Maintaining client ties, minimising transaction costs, and building long-term partnerships with all consumers are consequently essential. During after support, energy service providers maintain and strengthen their ties with their clients. Providing one-stop services, such as pre-purchase consulting, scheme design, mechanical installation, assistance for electricity supply, maintenance and surveillance system upgrades, and other offerings, is the most crucial activity under the host-owned concept. Companies can also provide advice and education services in how to manage the PV system, as well as sell relevant PV technology components like panels and processors.

Security policies

The growth of distributed photovoltaic systems may have favourable external consequences on the energy sector, the environment, and other areas. The administration must help distribution photovoltaic sectors to overcome unfavourable external impacts in economic terms by establishing the policies of economic advantages for solar power generation since overpriced expenditures and operational cost prevent their broad applicability. In terms of security measures, the administration should place a high priority on the training of diffused photovoltaic specialists and continue to provide financial support for the sector while maximising the use of the current industrial strategy. Regarding promoting policies, it is crucial for the government to increase cooperation in the development and implementation of distributed photovoltaic systems, implement measures like providing loans and tax exemptions to support the industry's research and innovation, and address issues like the low rate of photoelectric transformation by advancing the technology of photovoltaic modules. To encourage integrated growth of the grid and centralised energy, coordination regulations should strengthen the distributed photovoltaic admission process under the direction of win-win collaboration.

Results and Discussion

In this section, the various results are discussed for distributed solar PV system in the aspect of business model. Local market elements, such as connections to consumers, neighborhoods, banking firms, and recourses like dealers and celebrities, are the main source of information for electricity service organisations. The municipal council is crucial to the growth of DSPV power since it may offer substantial subsidies, encourage technological advancements, and promote DSPV electricity. Local dealerships are adept at utilising a variety of channels and consumer services, including techniques for engaging clients and identifying future requirements, individual interests, and way of life considerations. To build and further promote the business's brand image, community, current clients, and local celebrities may all help. This is due to the fact that these clients are influential, have large incomes, and are passionate about ecological sustainability. In addition, excellent technical and human resources are required to guarantee the quality of PV system installations. Additionally, it's critical for businesses to have solid reputations and brand perceptions. This aids in creating barriers against rivals, luring new partners, and bringing about further advantages.

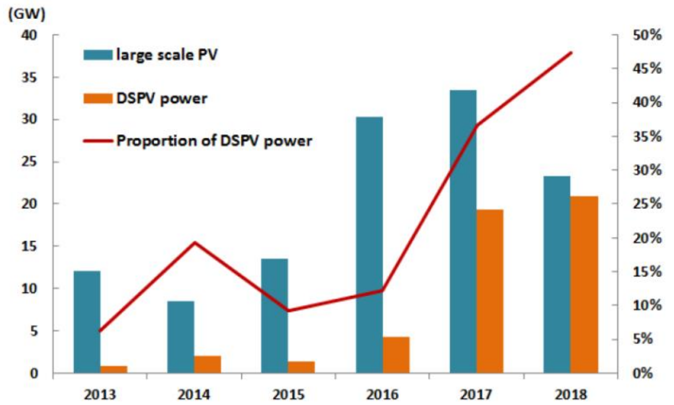

Figure 3: Capacity of PV through 2013 to 2018

The figure 3 shows capacity of PV from 2013 to 2018. The installed capacity of DSPV power in nation was about 48.52 GW selected to develop DSPV power.

Figure 4 shows volume changes record of DSPV capacity. The country decided to create DSPV electricity for two primary reasons. First, DSPV electricity has a lot of potential to advance energy consumption practises in both urban and rural regions and to improve the ecological environment. Second, the PV sector in China is one of the few that has the potential to rule the world market. Increased DSPV power might considerably foster and generate new sources of economic growth, enhance environmental and steady economic and social development, and aid in the sound development of critical developing sectors.

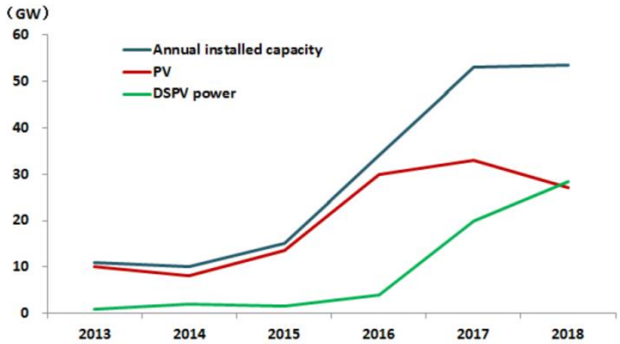

Figure 4: Volume changes record of DSPV capacity

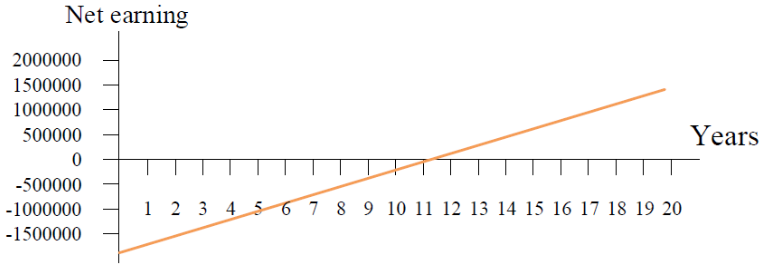

Figure 5: Value-added PV value-added service

Figure 5 illustrates how consumers might recoup the cost of the PV value-added service they purchased in around ten years.

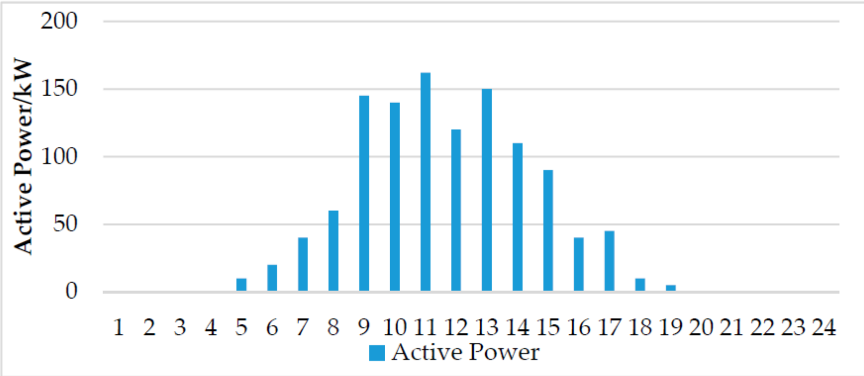

Figure 6: Active power prediction

Figure 6 shows prediction of active power. The photovoltaic active power prediction graphic displays the power trend of solar equipment over the next 24 hours. The output of the distributed photovoltaic system, which can be seen in Figure 6, was over 50 kW between 10 a.m. and 12:00 p.m., which was the peak time. Using forecasts to plan photovoltaic power production output would lessen the impact of ambiguous elements on the level and capacity of and such, effectively supporting the revision of past intends to produce and the creation of a plan for the day production sending.

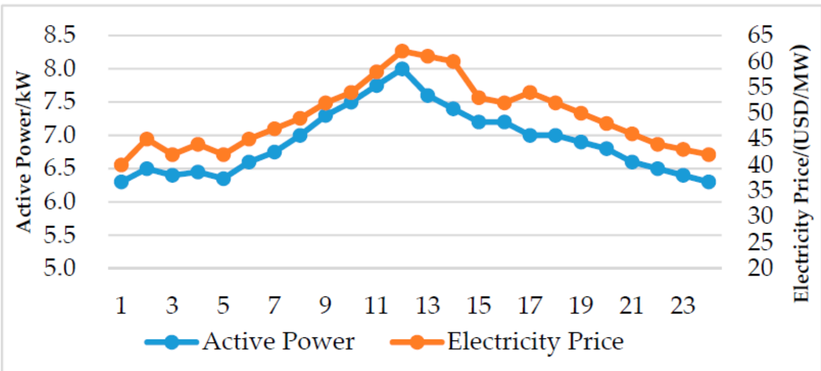

Figure 7: Electricity prediction

Figure 7 shows electricity prediction. The load at other periods of the day was changed based on the overall load of the reference scenario in order to maximise the generation dispatching. Figure 7 displays the 24-hour load and price projection based on the national pricing for solar energy generation.

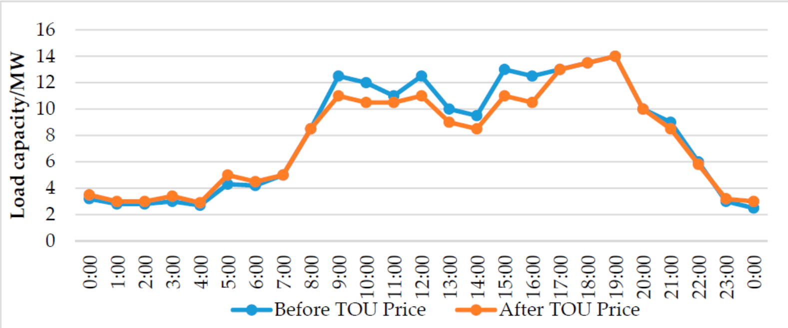

Figure 8: The load trends before and after the implementation of TOU price

Analysing the current data allows one to determine how the total load changed before to and following the adoption of the Time – Of – Use (TOU) price policy. Figure 8 displays the outcomes.

Conclusion

This research analyses the price of PV value-added solutions using Non - cooperative game behavioural economics. The ideal costing from each stage is discovered by addressing the issue of maximising financial gains in the multiple game paradigm, and a thorough pricing method is provided. The research study and calculations for Henan provide evidence of the model's mechanics, which shows that costs can be managed to recover and revenues can be quickly realised. The model used in this research may be created and evaluated in accordance with the real circumstances in any location and is not dependent on any photovoltaic System expected output. It is quite ubiquitous and has specific requirements for grid firms in terms of advertising.

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