

# Effect of COVID-19 on Photovoltaic Demand and Installation

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**Abstract:** The research investigates the effects of the COVID-19 pandemic on the photovoltaic (PV) sector. This research examines the alterations in PV demand and installation amidst the COVID-19 pandemic and identifies the underlying factors that have influenced these changes. The article delves into the difficulties encountered by PV installers amidst the ongoing pandemic. This study delves deeper into the effects of government policies and investor circumstances on the PV industry amidst the pandemic. It examines the policies that have influenced the supply chain, demand, financing, and shift towards renewable energy. The results suggest that the outbreak of the pandemic has resulted in noteworthy alterations in the demand and installation of PV systems, which have had both favourable and unfavourable effects on the sector. The response of the industry to the pandemic has been significantly influenced by government policies and investor conditions. The investigation culminates by proposing potential avenues for further inquiry within this domain.

## 1. Introduction

Energy is a crucial element in devising a viable solution to mitigate the effects of climate change. The combustion of fossil fuels for the purpose of generating electricity and thermal energy is a significant factor in the emission of greenhouse gases, which envelop the planet and retain solar radiation. There is a consensus within the scientific community that in order to mitigate the most severe impacts of climate change, it is imperative to decrease emissions by approximately 50% by 2030 and achieve carbon neutrality by 2050. The attainment of our goal is contingent upon the cessation of fossil fuel usage and the adoption of renewable energy sources that are readily accessible, reasonably priced, sustainable, and dependable. The COVID-19 pandemic has caused notable disturbances in the energy sector, potentially impeding the transition to renewable energy sources. Disruptions in the supply chain and concerns regarding the well-being of employees have resulted in significant disturbances in both the supply and demand of the energy industry. It was projected that the solar sector would augment its capacity by 130-135 GW in the year 2020. The outbreak led to various operational and financial challenges.

The COVID-19 pandemic has had a notable impact on the progress of renewable energy sources, leading to uncertainty regarding the trajectory of the energy transition [1]. The current outbreak has sparked intense discussions regarding the most effective approach to enable a worldwide shift towards sustainable energy.

The COVID-19 pandemic has hindered the progress of energy transition, despite the presence of various policies that indicate a favourable outlook for the advancement of renewable energy [2]. There is an increasing level of apprehension regarding the energy transition following the epidemic, as noted by Shah [3]. Following the World Health

Organization's declaration of the COVID-19 outbreak as a global pandemic on March 11, 2020, several nations have transitioned into a new phase of pandemic prevention and control. This has entailed significant limitations on travel and economic operations. According to the International Energy Agency (IEA) in 2020, there was a temporary cessation in commercial operations resulting in a 5% reduction in energy consumption and a 7% decrease in emissions on a global scale [4]. Shan et al. [5] posits that in the forthcoming decades, there is a possibility that it will have a prolonged impact on worldwide energy consumption and carbon emissions. The decline in the prevalence of the epidemic among the nations that are responsible for producing the bulk of the global oil supply has resulted in additional reductions in prices within the energy market. The decrease in oil prices has resulted in traditional energy sources being comparatively more affordable than renewable energy sources. The reduction in global trade resulting from pandemic lockdown measures had a significant impact on the global supply chain for renewable energy, contributing to the isolation of the virus and financial loss mitigation [1]. According to Sovacool et al. [6], the occurrence of vacations among workers in the renewable energy sector has resulted in a decrease in corporate productivity, thereby impeding the development, implementation, and utilisation of a significant amount of renewable energy technology.

The COVID-19 pandemic has been observed to have a positive influence on the advancement of renewable energy sources, as noted by Goodell [7]. In response to the epidemic, several governments have modified their investment approach to prioritise healthcare over alternative objectives such as tax benefits or renewable energy [8]. The absence of governmental assistance hinders investments in renewable energy due to the considerable initial expenses and the absence of immediate returns. Several nations are currently

deliberating on potential solutions to facilitate the recovery of their economies from setbacks. Although there has been an increasing demand for environmentally friendly stimulus measures, the allocation of funds towards such initiatives in the proposed stimulus plans has been relatively restricted. As a result, most nations have continued to prioritise investments in fossil fuels within their energy investment frameworks. The expeditious economic recovery endeavours are expected to yield enduring adverse effects on the global capacity to withstand and maintain ecological balance and continuity, particularly in the domains of climate change and energy conversion.

This study is arranged to determine the impacts of COVID on solar photovoltaics (PV) demand and installation, covering PV market pre and post COVID-19. The market under the restrictions of COVID will be evaluated where different regions markets will be studied to get an overall view. The outcome from this analysis will help in creating strategic policies measures, which are to be taken under pandemic/epidemic situations.

## 2. Regional Analysis

The COVID-19 pandemic has had varying effects on the demand for PV systems in different global regions. The COVID-19 pandemic has had varying impacts on the demand for PV systems across different regions, with some experiencing a decrease while others have observed an upsurge in demand (see Figure 1). The observed variations across regions can be ascribed to a multitude of factors, encompassing governmental policies and incentives, prevailing economic circumstances, and the extent of perturbations in supply chain operations.

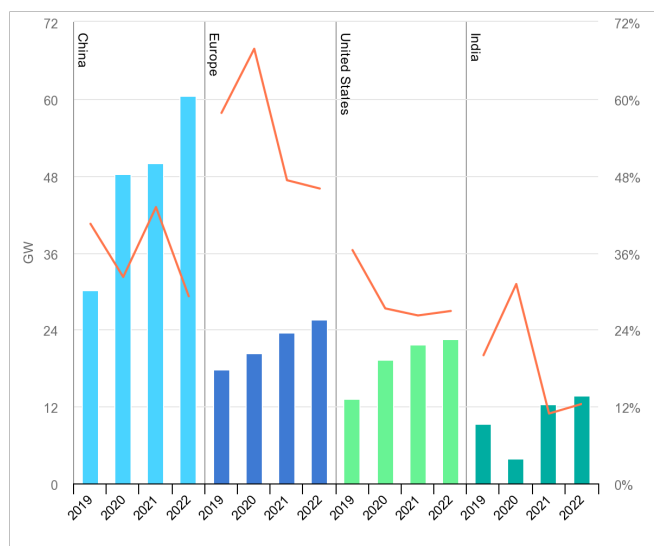


Figure 1: Annual solar PV capacity additions in selected countries [9]

### 2.1. China

Pre-COVID-19: Preceding the COVID-19 pandemic, the PV market in China held the position of being the most extensive globally. This was primarily due to the support of renewable energy by government policies and a swiftly

expanding economy. The market witnessed a surge in installed capacity by 19% from the previous year, amounting to a total of 30.1 GW in 2019. The expansion was propelled by the deployment of solar installations on both utility-scale and distributed levels, with a notable surge in interest from residential, commercial, and industrial consumers.

During COVID-19: During the initial quarter of 2020, the solar industry in China encountered the impact of the pandemic, leading to the closure of numerous factories and disruptions in the supply chain, thereby resulting in project installation delays. The government expeditiously executed measures to bolster the industry, including the extension of project timelines and the provision of financial assistance to companies impacted by the pandemic. Notwithstanding the obstacles encountered, the PV market in China exhibited fortitude in the year 2020, attaining an unprecedented installation capacity of more than 48 GW, signifying a 45% surge from the antecedent year. The primary driver of this expansion was attributed to utility-scale initiatives, which constituted more than 80% of the overall installations. The PV market in China exhibited a sustained expansion, propelled by robust requisites from public service companies, business enterprises, and individual households.

Post-COVID-19: The PV market in China is anticipated to persist in its growth trajectory, owing to the nation's objective of achieving carbon neutrality by 2060 and the robust backing of the government towards the advancement of renewable energy. Notwithstanding, there are still obstacles to overcome, such as problems with grid connectivity, challenges in securing financing, and a market that is fiercely competitive. The government has established specific objectives to achieve the apex of carbon emissions by 2030 and carbon neutrality by 2060. This is anticipated to generate additional prospects for the PV sector. In spite of the disruptions and challenges brought about by the COVID-19 pandemic, the Chinese PV market has demonstrated resilience and sustained growth. The market is anticipated to sustain its pivotal position in the worldwide PV sector and exert a significant influence on China's shift towards a low-emission economy.

### 2.2. USA

Pre-COVID-19: Prior to the onset of the COVID-19 pandemic, the PV market in the United States was undergoing consistent expansion, primarily attributed to the declining expenses and advantageous governmental regulations. The market witnessed a surge in installed capacity by 23% from the preceding year, amounting to a total of 13.3 GW in 2019. The expansion was propelled by robust requests from utility companies, businesses, and households, coupled with declining costs and advantageous regulations in select regions.

During COVID-19: The PV market in the United States was notably affected by the COVID-19 pandemic. The pandemic resulted in immediate supply chain disruptions, project delays, and labour shortages, which consequently led to a deceleration in installations during the initial six months of 2020. Furthermore, the economic uncertainties arising from the pandemic and the alterations in government policies and incentives have presented significant challenges for the industry.

Amidst the pandemic, the United States government sustained its backing for the implementation of sustainable

energy sources, such as solar PV technology, through the implementation of novel policies and incentives. The Solar Investment Tax Credit (ITC) was extended by the US Congress for a duration of two years in December 2020. This move is anticipated to offer stability and bolster the industry.

In the latter half of 2020, the PV market in the United States experienced a resurgence, marked by unprecedented levels of installations. The year 2020 witnessed a surge in the market's installed capacity, with a total of 19.2 GW being added, marking a 43% increase from the preceding year. The expansion was propelled by robust requests from utility companies, corporate entities, and residential consumers, alongside declining costs and advantageous regulations in select regions.

The United States PV market has experienced both favourable and unfavourable consequences as a result of the COVID-19 pandemic. The pandemic has resulted in supply chain disruptions, project delays, and labour shortages in the short term. Nonetheless, the market experienced a resurgence during the latter half of 2020, characterised by unprecedented levels of installations.

Post-COVID-19: The future trajectory of the US PV market is anticipated to exhibit sustained expansion, propelled by federal policies such as the Solar Investment Tax Credit (ITC) and state-level policies that endorse the adoption of renewable energy. Furthermore, the recent prioritisation of clean energy and climate change by the Biden administration is anticipated to generate additional prospects for the PV industry.

During the second quarter of 2021, the United States successfully implemented 5.7 GW of solar photovoltaic (PV) capacity, a sufficient amount to generate electricity for approximately 18.9 million households. The projected increase in capacity through 2021 and the anticipated surge over the next decade can be attributed to a substantial portfolio of projects and favourable federal policies. Therefore, based on the aforementioned factors, it is anticipated that solar PV technology will be the predominant source of energy in the United States' solar energy market over the next ten years.

Notwithstanding the obstacles posed by the pandemic, the PV market in the United States has demonstrated durability and persistent expansion. Amidst the pandemic, the solar industry was classified as an indispensable service, and numerous states instituted measures to facilitate the advancement of solar energy. In general, despite the adverse effects and obstacles brought about by the COVID-19 pandemic, the PV market in the United States has demonstrated its ability to recover and adapt effectively. It is anticipated that the market will sustain its growth trajectory and exert a significant influence on the nation's shift towards a low-carbon economy.

### 2.3. UK

Pre-COVID-19: Prior to the onset of the COVID-19 pandemic, the PV market in the United Kingdom exhibited consistent expansion, which was propelled by a reduction in expenses and advantageous governmental regulations. The market witnessed a rise of 31% in the installation of capacity, amounting to a total of 760 MW in the year 2019 as compared to the preceding year. The expansion in question was propelled by the implementation of both large-scale and

small-scale installations, with the latter being facilitated by the government's Feed-in Tariff (FiT) initiative and the Smart Export Guarantee (SEG).

During COVID-19: The UK PV market experienced a notable effect as a result of the COVID-19 pandemic. The COVID-19 pandemic resulted in short-term supply chain disruptions, project delays, and labour shortages, ultimately contributing to a decrease in installations during the year 2020. Furthermore, the economic uncertainties arising from the pandemic and the alterations in government policies and incentives have posed significant challenges for the industry.

Amidst the pandemic, the government of the United Kingdom sustained its backing for the implementation of sustainable energy sources, such as solar PV technology, through the implementation of novel policies and incentives. In July of 2020, the government disclosed a plan worth £3 billion to facilitate the decarbonization of public buildings, such as schools and hospitals. This initiative is anticipated to generate prospects for the PV industry. Furthermore, the government has implemented a Green Homes Grant programme aimed at facilitating the implementation of energy-efficient and sustainable energy alternatives in residential properties.

The COVID-19 pandemic had a negative impact on the UK PV market, resulting in a reduction in installations in 2020. Specifically, the installed capacity amounted to 545 MW, which represents a decline of 28% compared to the previous year. The decrease in installation was ascribed to the disruptions and uncertainties caused by the pandemic, as well as modifications in government policy and incentives.

Post-COVID-19: Notwithstanding the previous downturn, it is anticipated that the PV market in the United Kingdom will recover and persist in its expansion in the forthcoming years. The government has established ambitious objectives to achieve net-zero emissions by 2050 and has implemented policies and incentives to facilitate the implementation of renewable energy sources, such as solar PV technology. Moreover, the ongoing pandemic has presented prospects for the PV sector, including a surge in the need for residential energy alternatives and the implementation of virtual and telecommuting work methodologies.

As of November 2021, the United Kingdom has recorded a cumulative installed solar capacity of 13.63 GW. Of this, 3,218 MW, which accounts for 23.6% of the total installed solar PV capacity, is attributed to installations below 10 kW. These installations are predominantly comprised of residential rooftop solar photovoltaic consumers. Approximately 91.9% of all installations fall under the category of sub-4 kW.

In general, the UK PV market has experienced disruptions and difficulties as a result of the COVID-19 pandemic. However, this situation has underscored the significance of energy systems that are both clean and robust and has opened up prospects for expansion and originality within the sector.

### 2.4. India

Pre-COVID-19: The solar PV market in India witnessed significant expansion prior to the outbreak of the pandemic, primarily attributable to the government's ambitious objective of attaining a solar power capacity of 100 GW by the year

2022. There was a rise in investments in the market, resulting in a noteworthy decrease in solar tariffs. The solar sector was perceived as a significant catalyst for employment generation and economic advancement within the nation.

During COVID-19: Amidst the pandemic, the Indian government sustained its backing for the solar sector by introducing a number of initiatives, including the Atmanirbhar Bharat Abhiyan, which endeavours to encourage domestic production of solar equipment. Additionally, the government has introduced a production-linked incentive programme aimed at incentivizing solar manufacturers to produce high-efficiency solar modules. India's solar PV capacity demonstrated growth despite the obstacles encountered during the pandemic. The country accomplished a cumulative installed capacity of more than 40 GW by the conclusion of 2020.

Post-COVID-19: As of the conclusion of 2022, the aggregate installed capacity has attained a value of 410 GW, with a corresponding renewable capacity of 121 GW. Despite falling short of the 175 GW target for 2022 by approximately 30%, India's renewable sector has demonstrated continued growth, propelled by a policy emphasis on clean energy resources. As of the conclusion of 2022, there exists a renewable energy pipeline comprising over 70 GW, which is presently undergoing various stages of development. Approximately 40% of the aforementioned pipeline is experiencing delays that exceed its projected timeline, potentially resulting in a heightened probability of additional delays or cancellations within the present high-cost climate.

The solar PV market in India has been significantly affected by the COVID-19 pandemic. The industrial sector encountered a number of obstacles, such as disruptions in the supply chain, delays in projects, and a scarcity of labour as a result of migration. The COVID-19 pandemic has resulted in a reduction in energy consumption, thereby impacting the economic feasibility of certain solar initiatives. Notwithstanding the adverse effects of the pandemic, the government implemented diverse measures, including loan restructuring and project deadline extension, to alleviate its impact.

### **3. Findings**

#### *3.1. Impact of COVID-19 on PV Demand*

The COVID-19 pandemic has resulted in significant disruptions to supply chains, decreased consumer spending, and heightened economic uncertainty, thereby precipitating alterations in the demand for numerous systems [10]. The implementation of lockdowns and social distancing measures in numerous countries has had an impact on the purchasing behaviour of consumers, leading to a deceleration in the installation of PV systems.

The economic repercussions of the pandemic have emerged as a crucial determinant of PV demand during the ongoing crisis. Due to the pandemic-induced economic downturn and resultant job losses, a considerable number of consumers exhibited a reduced inclination towards investing in PV systems, which are known to entail significant costs. The COVID-19 pandemic has had an impact on the allocation of government funding towards renewable energy initiatives, leading to a subsequent decrease in demand for PV systems.

The pandemic-induced disturbance in supply chains has been identified as a contributing factor to the fluctuation in PV demand [11]. The COVID-19 pandemic has resulted in significant disruptions to the production and transportation of PV components, thereby posing challenges to suppliers in fulfilling customer orders. The circumstance has resulted in a postponement of the installation process and a surge in expenses for PV systems, ultimately leading to a decline in customer demand.

In addition, the demand for PV systems has been impacted by alterations in energy consumption behaviours resulting from the implementation of lockdowns and social distancing protocols. The curtailment of business and industrial activities amid the pandemic resulted in a decline in energy usage [12], which consequently led to a reduction in the market demand for PV systems. Furthermore, the outbreak of the pandemic has resulted in a surge in virtual work and digital engagements, thereby altering the energy usage trends and presenting novel predicaments for the PV sector.

The impact of the COVID-19 pandemic on the PV industry has resulted in notable alterations in the demand for PV systems, thereby influencing the industry's growth and development. The pandemic, supply chain disruptions, and alterations in energy consumption patterns have emerged as significant determinants influencing the demand for PV during the pandemic, particularly in terms of its economic ramifications. Comprehending these factors is of utmost importance for the PV industry to effectively navigate the obstacles presented by the pandemic and to formulate tactics to advance the adoption of sustainable energy practises.

The COVID-19 pandemic has resulted in changes in PV demand, which can be attributed to various factors. The economic impact of the pandemic is considered to be one of the most consequential factors. The implementation of lockdowns and social distancing measures by various countries to curb the spread of the virus has led to the closure or downsizing of several businesses, thereby causing a loss of jobs and creating economic instability [13]. The costliness of PV systems has resulted in a sense of reluctance among numerous consumers to make investments in them.

In addition, the pandemic has had an impact on the accessibility of funding for PV systems, resulting in a subsequent decrease in demand. The acquisition of PV systems by consumers is often facilitated through loans and other financing alternatives. However, the ongoing pandemic has resulted in market disruptions and a decrease in the accessibility of financing options [7]. The increased cost of PV systems has resulted in a reduction in demand as consumers find it challenging to afford them.

The disturbance in supply chains is an additional element that has contributed to the alterations in PV demand amidst the pandemic. The COVID-19 pandemic has resulted in disruptions to the manufacturing and logistics of PV components, posing challenges for suppliers in fulfilling customer orders. The aforementioned circumstance has resulted in the postponement of PV system installations and escalated expenses, thereby diminishing customer demand.

Moreover, alterations in energy consumption trends resulting from the pandemic have impacted the demand for PV systems. The curtailment of operations by various businesses and industries amid the pandemic resulted in a decline in energy usage, thereby causing a reduction in the

market demand for PV systems. Furthermore, the COVID-19 pandemic has resulted in a surge of telecommuting and virtual engagements [14], thereby altering the dynamics of energy consumption and presenting novel predicaments for the PV sector.

Government policies and incentives have been a contributing factor in influencing the alterations in PV demand amidst the pandemic. The COVID-19 pandemic has resulted in alterations to governmental agendas and financial allocations towards sustainable energy initiatives, consequently impacting the market demand for PV systems. The implementation of PV systems and the stimulation of demand can be facilitated by governmental policies and incentives. However, alterations in governmental priorities and funding may result in an adverse impact.

### *3.2. Impact of COVID-19 on PV Installation*

The outbreak of the pandemic has posed a multitude of challenges for installers, necessitating strict adherence to safety protocols to mitigate the transmission of the virus [15]. Consequently, novel techniques for installation have surfaced, while conventional approaches have undergone modifications to accommodate the evolving requirements.

The COVID-19 pandemic has resulted in the implementation of novel safety protocols in PV installation, representing a substantial modification in the field. In order to curtail the transmission of the virus, employees are now required to adhere to rigorous procedures, including the utilisation of personal protective equipment (PPE), observance of social distancing measures, and thorough disinfection of equipment and surfaces. The aforementioned measures have been implemented with the aim of safeguarding the well-being of both the installers and customers, thereby guaranteeing the secure and effective execution of installations.

The PV industry has witnessed a hastened uptake of digital technologies due to the pandemic. Presently, a considerable number of installers are utilising digital tools to oversee installations, encompassing the design of the system as well as the monitoring of its performance subsequent to installation. Consequently, there has been a notable enhancement in operational effectiveness and a decrease in expenses for both the service providers and clients.

The COVID-19 pandemic has resulted in substantial modifications in the implementation of PV installations. In order to guarantee the secure and effective installation of PV systems, installers have been required to adjust to novel safety protocols and embrace fresh installation techniques. The alterations that have been made have posed difficulties, but they have also stimulated ingenuity within the field and expedited the implementation of electronic advancements. As the ongoing pandemic progresses, it is probable that the PV industry will persist in its evolution and adjustment to cater to the shifting demands of the market.

The COVID-19 pandemic has resulted in alterations to PV installation, which can be attributed to various factors. The foremost consideration pertains to the requirement of complying with novel safety measures aimed at curbing the transmission of the virus. The implementation of social distancing guidelines has necessitated that installers adopt

novel installation techniques and adapt pre-existing methods to reduce physical interaction.

The impact of the pandemic on supply chains is a contributing factor to changes in PV installation. The outbreak of the pandemic has caused significant disruptions in the supply chains of various industries, including the PV industry. The occurrence of delays in the delivery of materials and components has resulted in a negative impact on the installers' capacity to timely finalise projects. Consequently, numerous installers have been compelled to adjust their installation timetables and implement novel tactics to guarantee timely completion of projects.

The COVID-19 pandemic has had an impact on the labour market, as noted by Paresashvili et al. [16]. This has resulted in challenges for installers who are encountering obstacles in locating qualified personnel to perform installations. The scarcity of labour has prompted the implementation of novel installation techniques, including remote installations.

Furthermore, the COVID-19 pandemic has had a significant effect on the economic sustainability of PV systems. The COVID-19 pandemic has resulted in financial challenges for both households and businesses, consequently causing a reduction in the demand for PV installations. The impact of this phenomenon on the financial gains of installations has prompted installers to devise novel approaches to entice customers and sustain profitability, as per Gebreslassie's findings [17].

The regulatory landscape for PV installations has been affected by the pandemic as well. Numerous governing bodies have implemented novel regulations and directives in response to the difficulties presented by the pandemic, as stated by Bolislis et al. [17]. The implementation of new regulations and guidelines has necessitated installers to adapt their installation methods and procedures accordingly.

In general, a multitude of factors have played a role in the alterations observed in PV installation as a result of the COVID-19 pandemic. The implementation of novel safety protocols, interruptions in supply chains, scarcity of labour, financial hurdles, and alterations in regulatory frameworks have collectively led to the adoption of fresh installation techniques and modifications to pre-existing ones. The COVID-19 pandemic has stimulated innovation within various industries, resulting in the implementation of novel strategies to surmount the obstacles presented by the pandemic.

## **4. Conclusions**

The global PV market was significantly impacted by the COVID-19 pandemic, leading to the conclusion that its effects were far-reaching. Notwithstanding the challenges posed by the pandemic, the PV market in China, the US, and the UK exhibited resilience and sustained growth. The Chinese government expeditiously executed policies to provide assistance to the industry, culminating in the establishment of installations at an unprecedented level in the year 2020. In the latter half of 2020, the United States government implemented novel policies and incentives aimed at bolstering the renewable energy sector, particularly solar PV technology. As a result, the market experienced a resurgence. The United Kingdom experienced a reduction in installations in 2020 as a result of the pandemic. Nevertheless,

the government persisted in its efforts to promote the implementation of renewable energy by implementing fresh policies and incentives. The PV sector is anticipated to persist in its expansion and exert a significant influence in the worldwide shift towards a low-emission economy. This trend is propelled by declining expenses, advantageous governmental regulations, and a mounting need from utility companies, businesses, and households.

The COVID-19 pandemic has had a noteworthy influence on the request for and implementation of PV systems. The COVID-19 pandemic has had a significant impact on supply chains, consumer spending, and economic stability, resulting in alterations to the demand for PV products. The COVID-19 pandemic, alterations in supply chain operations, shifts in energy consumption trends, and governmental regulations are among the primary drivers influencing PV demand amidst the pandemic. Moreover, the outbreak of the pandemic has posed difficulties for PV system installers, who have been compelled to conform to novel safety measures and embrace innovative installation techniques to guarantee the secure and effective installation of PV systems. Nevertheless, these modifications have also stimulated ingenuity within the sector and expedited the assimilation of electronic technologies. Given the ongoing evolution of the pandemic, it is probable that the PV industry will persist in its efforts to adjust and formulate tactics aimed at advancing the cause of sustainable energy consumption. The COVID-19 pandemic has had a noteworthy influence on the request for and implementation of PV systems. The COVID-19 pandemic has had a significant impact on supply chains, consumer spending, and economic stability, resulting in alterations to the demand for PV products. The COVID-19 pandemic, alterations in supply chain operations, shifts in energy consumption trends, and governmental regulations are among the primary drivers influencing PV demand amidst the pandemic. Moreover, the outbreak of the pandemic has posed difficulties for PV system installers, who have been compelled to conform to novel safety measures and embrace innovative installation techniques to guarantee the secure and effective installation of PV systems. Nevertheless, these modifications have also stimulated ingenuity within the sector and expedited the assimilation of electronic technologies. Given the ongoing evolution of the pandemic, it is probable that the PV industry will persist in its efforts to adjust and formulate tactics aimed at advancing the cause of sustainable energy consumption.

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