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REVIEW
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Solar Photovoltaic Energy Optimization and Challenges

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The study paper focuses on solar energy optimization approaches, as well as the obstacles and concerns that come with them. This study discusses the most current advancements in solar power generation devices in order to provide a reference for decision-makers in the field of solar plant construction throughout the world. These technologies are divided into three groups: photovoltaic, thermal, and hybrid (thermal/photovoltaic). As a result, this article begins by outlining the approach that will be employed to undertake this research. Following that, solar energy production methods are researched and their sub-classifications are described in order to establish their resource needs and features. Following that, a detailed conversation is held. Each technology's environmental and economic performance will be evaluated. Furthermore, a statistical analysis is conducted to emphasize the efficiency and performance of each solar technology, as well as to identify their global rankings in terms of power output. Finally, research trends in the development of solar power plants are presented. The credibility of the Photovoltaic system, types and limitations is the discussion under study system makes use of sun's energy to generate electricity with the help of varied procedural systems; stand-alone, hybrid or grid charged. Based on this research, it is possible to infer that the primary goals of optimization approaches are to reduce investment, operation and maintenance costs, and emissions in order to improve system dependability. This paper also includes a brief overview of several solar energy optimization problems and issues.

Keywords: photovoltaic, hybrid system, stand-alone system, grid system, energy, solar energy, renewable, clean energy optimization methods

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1 INTRODUCTION

Global warming is an element in climate change and explicitly refers to the influence of greenhouse gases on the overall surface temperature of the Earth. When describing extreme weather events produced by greenhouse gases; the label "global warming" is appropriate. When characterizing other long-term changes to the planet's weather patterns, however, climate change is the most appropriate phrase. Opponents of climate change and global warming have noted out how the Earth's temperature patterns have fluctuated for generations, and that current climatic changes are not as severe as stated, nor are they only the consequence of human activity.

The Earth's atmosphere is made up of several gases that work as a layer, trapping heat from the sun and blocking it from escaping back into space. Human actions have contributed to rising global

FIGURE 1 | Photovoltaic system (Flickr).

temperatures, according to 97% of active climate experts throughout the world. According to climate experts, such negativity arises from a fear of confronting the scale of the harm caused by human actions to the environment. Little fluctuations in the Earth's orbit around the Sun enable the ice sheets to develop and disappear. Solar radiation levels fluctuate. Such changes have a wide range of consequences in space, the Earth's atmosphere, and on the Earth's surface (Mohamed et al., 2014). Upshot changes in solar activity, according to current scientific opinion, have only a little role in the Earth's temperature. The warming induced by increasing levels of man-made greenhouse gas emissions is several times more than any other factors: Recent changes in solar activity are to blame. In fact, solar energy is a lot more beneficial for human beings. As the modern technological world is getting updated day by day. There is dire need to find a credible energy source in order to ensure a promising ground. In terms of solar energy, the sun is the most major source which can turn into feasible means if it is used to produce photovoltaic energy. Photovoltaic energy can be produced with the help of solar energy and is converted into electricity with the aid of solar photovoltaic panels.

Many activities rely on solar energy. Pumping water is mostly used in agriculture. PV panels and electric batteries are utilized to power the electro-pumps, allowing the irrigation system to be completely self-sufficient. In the construction sector, solar energy is used for air conditioning, water heating, lighting, and refrigeration systems. Desalination of water is another key application of solar energy. Solar energy is utilized to extract low-salt water from saltwater in this technique. Telecommunications is another key sector that makes use of solar energy. Satellites' electrical demands are met by solar panels installed on their spinning limbs. Solar energy is occasionally utilized as a backup power source for established telecommunications networks. Hydrogen generation and consumption by electrolysis of water is one of the most promising ways to achieving carbon neutrality by 2050. **Figure 1** shows the typical Photovoltaic system. Solar energy has shown to be the most cost-effective and environmentally friendly option for electrolysis procedures. For power generation, three primary technologies are used, namely thermal, photovoltaic, and hybrid thermal photovoltaic. Numerous nations have already implemented similar systems in their electrical grids, including the United States, Spain, Morocco, India, China, and. Furthermore, in order to select the most appropriate technology for a specific country, a thorough examination and knowledge of the many solar technologies and their underlying challenges is required to assist responsible institutions in making decisions. As a result, a comprehensive assessment of all solar technologies for energy generation is required. As a result, the purpose of this study is to cover several research gaps in the literature, such as the absence of statistical analysis of existing solar power plants throughout the world. Moreover, decision-makers will be able to implement the most appropriate solar power technology for a specific geographic region. The second gap in the literature concerns a recent comprehensive study of solar energy technology for power generation. The third significant research gap is an in-depth comparison of the performance of the three primary solar technologies and their modifications, which, to the best of the authors' knowledge, has yet to be addressed in any contemporary study.

As a result, the following are the primary additions and innovations of the present article:

- A new summary of the three primary solar methods for generating power.
- Updated solar technology economic and environmental assessments.
- Audit of linear Fresnel reflectors, parabolic trough technology, Parabolic dish collectors, Heliostat field collectors, photovoltaic, and concentrated photovoltaic solar power plants.
- PV-CSP and PVT/CPVT are two hybrid systems for generating thermal solar electricity (Getie et al., 2020).

The layout of this paper is as follows. Section *methodology* introduces the adopted methodology in this review paper. Section *Technologies Overview for Generating Thermal Power* describes the three main solar technologies for electricity production. The discussion and comparison of these technologies alongside future trends and evaluation of their environmental and economic aspects are conducted in section Discussions. Section *Optimization Method* discuses *PV Base Hybrid System, PV Based Grid System and PV Based Standalone System.* Section *Utilization of Solar Photovoltaic Energy* discusses application. Section *Optimization Issues and Challenges* highlight limitations, while Section *Conclusion*, provides the conclusion of this paper (Bishoyi and Sudhakar, 2017).

2 METHODOLOGY

An accurate literature study was undertaken to assess the most recent relevant research and their conclusions in order to investigate solar technologies for power production. These latter have been investigated based on the accepted solar technologies, their working principle, their capabilities, and the environmental difficulties linked with them. Moreover, an analysis of the operating solar-powered power plants has been created. Finally, a comparison of all technologies is offered in terms of their advantages, efficiency, and resource needs. The paper covers an exact literature study to assess the most recent relevant research and their conclusions in directive to solar energy technology for electricity generation built on the solar techniques employed, their operating principles, and their performance. A list of all operational solar-powered power plants has also been established. A comparison of technologies in terms of their advantages, productivity, and reserve needs is presented as well. The review of literature is divided into three parts, the first of which was to gather the most recent information on the four essential technologies used in thermal solar stations (Zhang et al., 2013) as follows:

- Parabolic trough collector (PTC) (Ouagued et al., 2018).
- Linear Fresnel Reflector (LRF) (Ghodbane et al., 2016).
- Heliostat field collector (HFC) (Eddhibi et al., 2017).
- Parabolic dish collector (PDC) (Chen et al., 2018).

Second part splits research into two areas based on the major technology used in solar power plants:

- Fundamentally as Photovoltaic (PV) (Lokar and Virtic, 2020).
- Concentrated photovoltaic (CPV) (Aqachmar et al., 2020).

Third part, the technologies used in hybrid thermal photovoltaic systems are investigated. Including:

- Photovoltaic thermal (PVT) (Aqachmar et al., 2020).
- Concentrated photovoltaic thermal (CPVT) (Bamisile et al., 2020).

Next section shows a detailed literature review in order to shed light on different optimization methods in terms of solar photovoltaic energy. Furthermore, an overview on utilization of photovoltaic energy is presented. In the last step the cons of optimization methods are discussed in terms of challenges and issues to get a better understanding of debilitated points of this whole phenomenon.

2.1 Technologies Overview for Generating Thermal Power

DNI (Direct Normal Irradiance) is used to turn sunlight into electricity, solar thermal power uses the second principle of thermodynamics. This transition necessitates the use of two heat sources: a cold and a hot source. The heat transfer fluid (HTF) is employed as the hot source and water as the cold source in CSP power plants. Entropy is increased as a result of the natural heat exchange between water and HTF. After that, the HTF is heated using one of four different technologies: parabolic trough collectors, Fresnel reflectors, parabolic dish collectors, or solar power tower (Alsaffar, 2015).

2.1.1 Plants Using PTC Technology

A solar field, a power block, and thermal energy storage (TES) are all parts of the PTC power plant. In the solar field, solar collectors with parabolic troughs and tubes filled with a heat transfer fluid (HTF) are employed. By way of it passes through the tubes, a reflected beam of solar light heats the HTF. The power block must be efficient and trustworthy because it is the core of the PTC system. As a result, Rankine or Hirn cycles are the most often used power blocks (Zhar et al., 2021; Aqachmar et al., 2019). PTC power plants are already operational in 98 countries, with 43% in Spain, 7% in India and 17% in the United States. The capacity of these PTC plants between 0.15 MW in France to 2,474.5 MW in Spain (Solar paces, 2019; Boukelia et al., 2017). As indicated in **Table 1**, the LCOE of PTC power plants ranges from 0.07 to 0.23 USD/KWh, and is heavily impacted by the plant's position (DNI), size (Capacity in MegaWatts), and TES time. This table covers a number of LCOE optimization studies were carried out for a number of PTC plants in various countries (Boukelia, et al., 2017; Dowling et al., 2017; Aly et al., 2019; Achkari and El Fadar, 2020).

2.1.2 Heliostat Field Collector or Solar Power Tower

Large mirrors reflect the sun's energy onto a receiver at the top of a tower in heliostat field collector power plants. Ceramics or any other physical substance that is stable at high temperatures is used to construct the receiver. The heat is subsequently transferred to the HTF, which, in turn, is used to generate electricity, when it reaches a particular temperature, activates the steam generating system. The focused solar radiation must reach the receiver at a rate of 200–1,000 kW/m^2 (Simsek et al., 2018) to produce the required temperature for the procedure. In general, water, melted salt, sodium liquid or air, can be used as the HTF in SPT technology. Economic and technological research on SPT power plants have grown in popularity in recent years. This would include viability and optimization research, which necessitate an assessment of the power plant's three components: the heliostat field (tower altitude, land-use factor, as well as the quantity, length, and width of separate mirrors (heliostats)), heat energy storing (area for storage, storage extent, storing capacity), and power generation, vessels, temperature levels), (Chen et al., 2018; Simsek et al., 2018; Collado and Guallar, 2019; Zhuang et al., 2019; Awan et al., 2020a; Agyekum and Velkin, 2020; Hakimi et al., 2020), and electricity cycle (thermal cycle, fluid transmit, effectiveness, boiler stress, etc.). Awan et al. (2020b) obtained a 35.6% gain when compared to the initial design, full load storage period (TES) required for multi-objective optimization, tower elevation, and SM resulted in a 35.6% increase in energy competence and a 16.9% drop in LCOE. Zhuang et al. (2019) showed a cost-benefit analysis of 100 MW SPT power stations in China utilizing various melted salts and anticipated that the LCOE in China will fall from 0.23 $/kWh in 2017 to 0.10 $/kWh by 2050. In a recent study from Chile looked at the impact of solar extinction on LCOE (Marzo et al., 2021).

TABLE 1 | Current PTC power plant design optimization simulation research (Zineb et al., 2021).

Current PTC power plant design optimization Simulation research

Country	Study	Year of study	Capacity (MW)	Daily TES capacity (h)	LCOE ($/kWH)
India	SAM	2017	100	6	0.18
Tunis	SAM	2016	50	7.5	0.23
Algeria	ANN	2017	50	4.5	0.07564
China	OECD MODEL	2017	50	4	0.183
Libya	SAM	2018	50	7.5	0.24
Chile	SAM	2018	100	14	0.07564
Malaysia	SAM	2019	50	0	0.183
Kuwait	SAM	2020	300	7.5	0.129
Egypt	SAM	2020	50	0	0.116
Iran	SAM	2020	20	12	0.17
Saudi Arabia	SAM	2020	50	7.5	0.167
Ghana	SAM	2020	100	12	0.115
Afghanistan	SAM	2020	110	7.5	0.14
Tanzania	SAM	2021	50	4	0.107–0.12
Pakistan	SAM	2021	100	12	0.1
Cameroon	SAM	2021	5	0	0.23
Morocco	ANN and RSM	2021	1	8	0.14
India	SAM	2021	5	0	0.14–0.21
Spain	SAM	2021	50	4	0.24

TABLE 2 | Cost-benefit analysis of CSP technology in Indian climatic regions (Zineb et al., 2021).

Cost benefit analysis of CSP technology in indian climatic regions

Parameter	Linear fresnel reflector	Solar power tower	Parabolic trough collector
Net capacity (MW)		50	
Useful life (tcsp)		25	
Capital cost million $/MW	1.64	2.07	1.39
Heat transfer fluid	Thermal Oil	Molten salt	Water
Field aperture (m^2)	86,159	1,289,122	862,848
Design inlet temperature (°C)	293	350	230
Design outlet temperature (°C)	391	574	440
Solar multiple	1.4	1.4	1.4
Irradiation at design (w/m^2)	950	950	950
Land area (km^2)	1.25	1.34	0.54
Power cycle	Steam Rankine	Steam Rankine	Steam Rankine
Location		Jodhpur	
Climatic zone		Hot and Dry	
DNI ($kWH/m^2/yr$)		2,237	
CUF	0.19	0.32	0.24
LCOE ($/kWH)	0.15	0.13	0.14
Annual generation of electricity (MWh/yr)	85	139	104,000
Payback period (years)	10.74	2.73	7.21
Location		Leh	
Climatic zone		Cold	
DNI ($kWH/m^2/yr$)		2,536	
CUF	0.2	0.3	0.24
LCOE ($/kWH)	0.15	0.14	0.14
Annual generation of electricity (MWh./yr.)	86	131	103,000
Payback period (years)	10	6.43	7.82

2.1.3 Solar Thermal Power Plant With a Linear Fresnel Solar

An absorber, a steam generation system (SGS), a tracking system, and an instrumentation system all employ a collection of Fresnel reflectors built of linear mirrors (Ghodbane et al., 2019). LFR flat mirrors reflect the sun's straight normal irradiance (or ray radiation) towards absorber surface (Islam et al., 2018). As a result of the strong sun radiation, the water vaporizes. The steam turbine is spun by the evaporated water, which subsequently generator to produce electricity by rotating, thanks to the high pressure. As demonstrated in the study of a 120 MW LFR power plant in

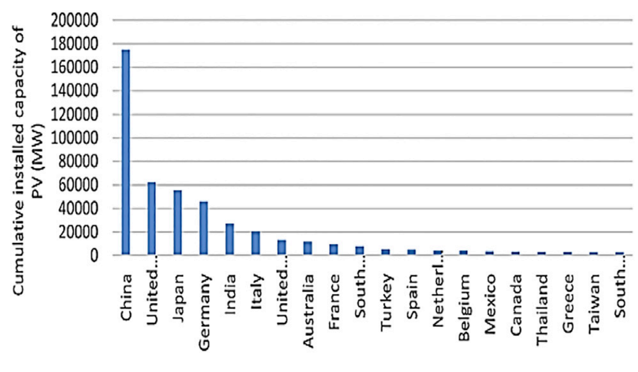

FIGURE 2 | Installed capacity of PV (MW) (Zineb et al., 2021).

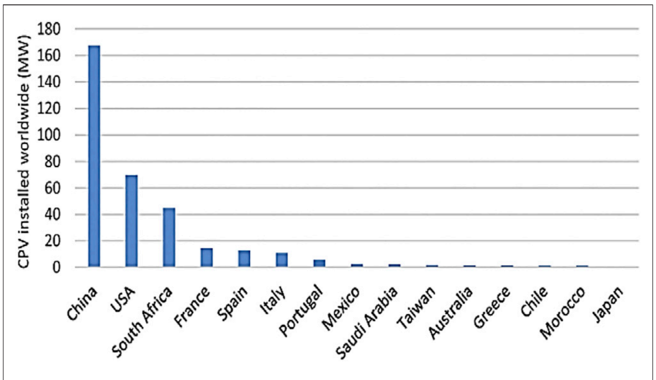

FIGURE 3 | Total Installed CPV worldwide (Zineb et al., 2021).

the El-Oued region (Alotaibi et al., 2020) (LCOE 14 0, 0382$/kWh; avoided CO_2 14,420, 67 tCO_2/year) and in India (Bishoyi and Sudhakar, 2017) for countries with significant water stress, Fresnel reflector-based power production technology is a very promising and low-cost technology. However, when compared to other technologies, particularly PTC (Bellos, 2019), in the solar industry, LFR power plants undergo from considerable optical losses. Sanda et al. (2019) gave a thorough review of thermal modeling and visual simulation tools for LFR power plant design. The prices of 50 MW LFR power plants are compared to PTC and SPC power plants in **Table 2** with equivalent capacity in India's diverse climatic zones (Kumar et al., 2021). Several researches on various aspects of LFR power plants, the thermal energy storage system, for example, have been installed to improve the plant's efficiency. By segregating the TES system from the rest of the system, into numerous modules (Tascioni et al., 2020), established a fresh optimization strategy. This resulted in a 13% improvement in TES efficiency and a 30% reduction in solar field thermal loss. Lopez et al. (2020) were also able to improve the economic and energetic performance of an Iranian power plant by adopting phase change material (PCM) as the storage system.

2.1.4 Power Plants for Parabolic Dish Collectors

The parabolic dish collector (PDC) is a technique that directs solar energy beams gathered by a dish-shaped concentrator to a receiver at its focal point. Flat and cavity receivers are the two types of receivers. To track the direct normal irradiation, the concentrator uses a two-axis tracker. For optimal use of the obtained focused heat, at the focus point, an electrical generator with a Stirling-Brayton mechanism is placed (Islam et al., 2019). When the ratio of concentrations surpasses 3000 (Islam et al., 2018; Lopez et al., 2020), the pressure and temperature in the receiver might reach dangerous levels 200 bar and 700–750°C, respectively.

2.2 Photovoltaic Solar Energy Technologies Are Used to Generate Solar Power

2.2.1 PV Technology

PV technology is frequently used because to its simplicity in power generation. As seen in **Figure 2** according to this, China (36%) leads the world in PV installed capacity, followed by the United States (13%), and Japan (11%) (IEA, 2020). China is generating more than 175.01 GigaWatts of PV power, with the United States and Japan 62.2 GigaWatts, 55.5 GigaWatts coming in second and third, respectively.

2.2.2 Concentrated PV Technology

Concentrated PV (CPV) cells were developed as a result of scientific advancements in the optical instruments field. The CPV focuses sunbeams onto PV cells with the help of utilizing an optical concentrator, such as a curved mirror or a lens. The solar cells' efficiency improves as a result of the additional photons focused with the concentrator. Adding a concentrator to a cell, according to the literature, enhances the current generated by the cell and improves the efficiency of the cell operating voltage (Gonzalez-Longatt, 2005; Luque and Hegedus, 2011). Appropriate concentration technology selection is critical because the performance of the CPV's optics has a direct and significant impact on the CPV's efficiency. As a result, **Table 2** provides a detailed summary of various concentration schemes. Two (or more) concentration systems are sometimes combined to improve the efficiency of CPV systems. **Figure 3** shows the total electricity generated by different countries utilizing CPV. CPV's installed power ranges up till 2021 from 114 kW in Japan to 67.68 MW in China region. Concerned nations' typical CPV output is around 22.43 MW. Moreover, China has half (50%) of the mounted CPV volume, tracked the United States having 21%. High concentrated PV (HCPV) accounts for 81% of installed CPV power plants, while low concentrated PV (LCPV) accounts for 19%. As a result, HCPV generates 93% of the produced electricity, whereas LCPV generates just 7%.

2.3 Hybrid Solar Thermal Power Generating Technology

Decoupled Photovoltaic and connected PV-CPV/CSP are the two types of hybrid solar power systems. These are systems that combine the two technologies on one worksite. Photovoltaic thermal collector (PVT) or concentrated photovoltaic thermal collector (CPVT) systems are dense or coupled hybrid solar systems that combine CPV/PV and CSP into a sole system are the second type of hybrid solar systems.

TABLE 3 | Hybrid PV-CSP technology (Zineb et al., 2021).

Hybrid PV-CSP Technology						
Location	**PV**	**BEESS**	**CSP**	**TES**	**Study**	**LCOE**
Spain, United States, Chile	100 MW	-	110 MW	-	Multi-objective optimization of hybrid solar power plants with thermochemical energy storage	Seville SPAIN: 0.177$/kWh Tonopah United States: 0.153$/kWh Atacama CHILE: 0.12$/kWh
Chile Atacama	150 MW 1 axis tracking p-cSiLCOE = 0.036–0.044 $/kWh	-	130 MW LCOE = 0.12–0.15$/kWh	Two molten salt tanks direct 287°C 565°C 13 h	-	PV + CSP without restriction SM = 2 0.055$/kWh
Chile Cera Dominador	100 MW 1 axis tracking cellule monoccSi	100 MW	Tower steam Rankine cycle 39.12% efficiency	17.5 h. Two molten salt tanks direct 295°C 565°C	Annual optimization varying the time	For 5 min time resolution 0.088$/kWh
Chile Carrera	16.9% efficiency	400 MW		14 h	Resolution	0.0768 $/kWh
DNI = 900 W/m^2	2 MW 2 axis tracking polycrystalline	-	8 MW 40% efficiency SM = 3.5	2 molten salt tank direct 290°C 570°C 12 h	Capacity configuration method	0.139 $/kWh reduce LCOE by 5.6% to CPS plat
Chile Crucero	100 MW 1 axis tracking m-cSiLCOE = 0.092 $/kWh	0 250–500 MW	Tower Steam Rankine cycle 39.12% efficiency LCOE = 0.132 $/kWh	two molten salt tank direct 295°C 565°C 12 h	Techno- economic analysis TRANSYS	0.0984 $/kWh 0.11–0.13$/kWh
China	30 MW	14.6 MW	30 MW	-	Genetic	by day
Lhasa	1 axis tracking p- cSi	9 MW			algorithm optimization	0.066 $/kWh Annual 0.055 $/kWh
Chile Atacama1	100 MW LCOE = 0.09$/kWh 870 tCO2 avoided	-	100 MW 37% efficiency LCOE = 0.132$/kWh	17.5 h	Two-stage multi- objective optimization	0.117 Reduce LCOE by 5.6% and the loss of power by 90% Initial: 0.124 $/kWh
China Lhasa	20 MW 1 axis tracking p- cSiLCOE = 0.161$/kWh	9 h	20 MW LCOE = 0.271$/kWh	two molten salt tanks direct 290°C 565°C 6 h	Analysis of the annual thermal and economic performances of the thermal storage PV-CSP	0.172 $/kWh decreased by 22.6% compared with the stand- alone CSP

2.3.1 Hybrid PV-CSP Technology

PV-CSP hybrid expertise is relatively different topic which has piqued the curiosity of scientists all over the world. By expanding hybrid power plants on large scale, this is especially promising, according to the IEA's solar thermal energy technology roadmap. The fascinating properties of such a combo, that can enhance system stability, enhance energy quality, cut LCOE, limit heat losses, and increase efficiency of power plant, driving this decision. The strategy for hybrid PV-CSP power plants on a large scale includes a battery energy storage system i-e (BESS) plants in recent research. The expected drop in battery costs may make this option more realistic in future. Several modeling researches dedicated to hybrid decoupled PV/CSP systems are included in **Table 3** (Gaga et al., 2017; Ju et al., 2017; Moukhtar et al., 2021). Conventional PV-thermal hybrid solar systems. A standard photovoltaic module is combined by a thermal accumulator in the PVT solar system to harvest sun energy. Several investigations have been conducted into this (Hissouf et al., 2020).

PV-thermal hybrid solar systems with concentrated photovoltaic. CPV technology, despite its high conversion ratio, is not without flaws, has serious flaw: excessive PV cell heating. A cooling technique is essential to avoid this. In this case, incorporating a thermal procedure achieve dual goals of freezing the CPV cells while also producing valuable thermal heat. The development of hybrid CPV-thermal technology was sparked by this.

2.3.2 Discussion of Thermal Methods for Energy Generation

Thermal technology for energy generation may be split into four groups, according to the review: solar power tower, parabolic dish collector, parabolic trough collector, linear Fresnel reflector, and the parabolic dip is the most commonly used solar thermal technique, having 64 percent of all CSP installation units in operation. Following that is tower technology, which accounts for 31% of all CSP technology installed globally. On either side, because PDC and LFR are two separate entities, they are relatively new technologies with considerable obstacles to overcome, their contribution to the energy mix are fairly limited. Because the performance of each technology is influenced by a variety of elements such as geographic location and HTF used, selecting one technology over another for a given place should be based

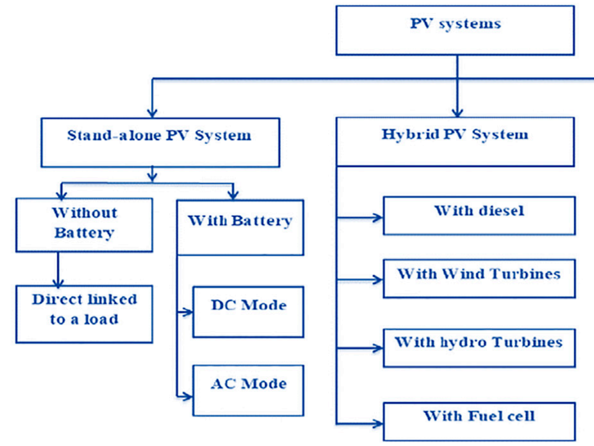

FIGURE 4 | Types of solar photovoltaic systems (Assadeg et al., 2019).

on these features. The conclusions of this study revealed the barriers to widespread CSP implementation. PDC, for example, is expensive; PTC has low conversion efficiency; and LFR devices have a restricted operating temperature. Furthermore, the significant both the SGS and the cooling process make use of water is a serious issue with CSP facilities. The focus on resolving these difficulties will improve CSP plant acceptability in the background of the global energy alteration.

2.3.3 Photovoltaic Technology Power Generation Discussion

Photovoltaic technologies for power generation are the focus of the present research. Depending on whether or not a concentrator is used, photovoltaic technology may be divided into two groups. Attempting to provide a simple summary of mounted CPV and PV systems across the world, regardless of the fact that CPV has a higher efficiency than PV, the accumulative capacity of CPV mounted globally is small, according to the statistics presented. The comparatively great prices of Concentrators and trackers for CPV explain this result (Aqachmar et al., 2020) directed a viability evaluation of CPV large scale facilities and provided unique policy solutions for addressing the problem of high CPV device pricing. In addition (Laarabi et al., 2021b), looked at the soiling problem. In both Morocco and India, the authors reviewed a large amount of literature on PV soiling measurement methodologies, impacts, and cleaning approaches, further showed that soiling is a much localized process, with the position of the plants having a substantial influence on soiling.

2.4 Discussion of Hybrid Technologies to Produce Electricity

According to the findings of this study, hybrid photovoltaic thermal technology may be classed as either traditional PVT or concentrated PVT. The hybrid PV or CPV achieves a dual goal of cooling the PV cells, so increasing electrical output, and providing usable thermal heat for thermoelectric generators. It is worth noting that hybrid solar technologies, whether coupled or decoupled, are still in their infancy and will require more development before being utilized in large-scale power facilities. This covers, among other things, optimizing optical concentrators, water usage, and investment costs. Next section will cover solar photovoltaic energy system types and solar energy optimization method, issues and challenges (Laarabi et al., 2021b).

2.5 Types of Solar Photovoltaic Energy System

Figure 4 shows types of the solar photovoltaic systems which includes the most common configuration - a grid-connected PV system, which is used when customers want can reduce their energy costs, and the grid is accessible for using when the array PV is not generating electricity. A "Utility-Interactive PV System or Grid Tied PV System" is a PV-array without the need of a storage system; it is directly connected to the grid. Solar panels that generate part, if not all, of their power demands during the day while staying linked to the local electrical grid at night are included in these Connected Grid PV Systems. In most connected grid PV schemes, extra or surplus electricity is stored in batteries or sent back into the electrical grid. Solar energy can be utilized to meet some or all energy needs for those with a connected grid PV arrangement in their houses and buildings. Moreover, since this type of PV system is indefinitely linked to the grid, there is no need to calculate solar energy consumption or solar panel sizing, enabling for a variety of options, including a system as limited as 1.0 kiloWh on the tower to dramatically lessen your electricity bills, and a much bigger ground assembled array large enough just to totally eliminate your electricity costs completely. Hybrid PV systems are similar to stand-alone ones. The goal of a hybrid power system is to generate as much energy as possible from renewable sources while meeting load demand. An? AC or DC distribution system, a storing system, filters, converters, and a load management or supervisory system are all possible components of a hybrid system, in addition to energy sources. All of these elements related in a different ways. Depending on the system size, renewable energy sources can be linked to the DC bus. HPS systems can generate power ranging from just few watts for personal usage to very few megawatts for modest community electrification systems. As a result, DC loads are frequently supplied by hybrid systems used for extremely low-power applications. Commonly linked with more than 100 kW of power as well as an AC bus are intended to be a component of the system of massive interconnected networks. Furthermost hybrid systems like a UPS system, can serve as a backup power supply during a blackout due to their ability to store energy (Georgescu-Roegen, 1979; Furkan and Mehmet Emin, 2010; Raturi, 2019). The word "hybrid" in the solar field refers to a system that employs a combination of solar and batteries and may interact with the power grid. The most cost-effective hybrid system employs a basic hybrid inverter, which includes a solar inverter and a battery inverter/charger, as well as smart controls that determine the most efficient practice of your available energy. PV system, stand-alone are suitable for sequestered rural areas and uses in which other sources of power are troublesome/nonexistent for powering lighting, applications, as well as additional equipment. This is frequently additional cost efficient for installing a solo stand-alone PV system to having local energy provider spread the power cables and lines directly towards the house as part of a grid-connected PV arrangement. A simple PV system is a self-contained solar expertise which produces electricity throughout the day to charge batteries for usage whenever the sun energy is absent at night. Rechargeable batteries are used to storing the electrical energy generated by panels (PV) or an arrangement in a stand-alone small-scale PV system (Farh et al., 2018). The battery allows an independent photovoltaic system to run when the solar panel itself does not generate enough energy, because the size of the battery is proportional to the power previously consumed. The two main types of batteries used to store solar energy are deep cycle batteries and shallow cycle batteries. Batteries are necessary component on which every standalone self sufficient solar power system relies. It also transforms electric energy into chemical energy which then is stored for usage anytime the solar array is not generating electricity. The PV system provides direct electricity to the load during daylight hours, with any extra energy being stored in batteries for later use.

3 OVERVIEW OF SOLAR ENERGY OPTIMIZATION METHOD

Solar energy systems emit no noise and produce no pollutants during operation and maintenance. Photovoltaic cell technologies have less environmental dangers than other forms of electric energy sources (Otero et al., 1998). Chemicals used in the manufacture of PV cells, on the other hand, might be discharged into the air, surface water, and groundwater in the production plant, installation site, and disposal or recycling facility. The solar collector storage system may provide energy at temperatures greater than the ambient outside air. A significant quantity of CO_2 is emitted by a PV power plant based on single crystalline silicon technology. There was no pressing necessity for optimizing the energy balance of the production process in the so far very modest PV sector. The analysis of the affecting solar energy system optimization, as well as operational characteristics, is critical aspects in improving power conversion efficiency. The climate has a considerable influence on the solar energy's reliability systems. As a consequence, optimization tactics are crucial in boosting the solar system's reliability and efficacy. To accomplish so, strategies for tackling challenging PV system optimization difficulties must be developed.

3.1 Optimization Method for PV Base Hybrid System

3.1.1 Hybrid Renewable Energy System

Wind turbines, photovoltaic, mini hydro, and/or anything else fossil-fuel-powered producers are all examples of hybrid power systems. Small systems that can power a single home to big systems that can power a colony or an island, these systems come in a variety of sizes. Many isolated locations, especially those in developing countries in which the grid operator is economically and technically non-viable, will benefit from hybrid power systems. In 1978, the first rural hybrid energy system systems, which included solar panels and diesel generators, were built in the United States. Until an electric grid was connected to the hamlet, the power generated by the system was used to power the communal laundry machine, refrigerator, stitching machine, lighting and water drives. Photovoltaic (PV), Micro hydropower (MHP) and tiny wind power bases are routinely used to provide electricity to clients in remote locations, with or without energy storage systems. Varied energy sources have different properties in terms of production, like as seasonal river flows, strong sunlight during the day rather than at night, and high wind speeds in the summer. Commercial PV or wind systems that operate they do not create power 24 h a day, 365 days a year. When PV and wind are combined, the battery bank capacity and fuel requirements (if a conventional generator is utilized as a backup) are reduced, among other benefits. However, in order for a hybrid PV-Wind system to work, the area must have a high potential for both solar and wind energy. Environmental conditions, PV capacity, wind generator capacity, storage device capacity, generating location, and other factors all have a significant impact on the hybrid PV/wind-diesel system's operation, maintenance, and cost (Prakash and Khatod, 2016).

Extra energy is stored in battery banks, which are then used to power the devices, load when the hybrid system is underpowered. The inverter (DC/AC) must convert to fulfill consumer load demand, the voltage is converted from DC to AC. The battery charger's output terminal, the storage battery, and the input terminal of the (DC/AC) converter are all linked in equivalent. Because fluctuations in solar radiation and wind velocity have a significant impact on energy generation, hybrid systems must be carefully designed to ensure a consistent power supply to clients in changing climatic conditions. Similarly, to keep system costs low, a detailed design should be conducted.

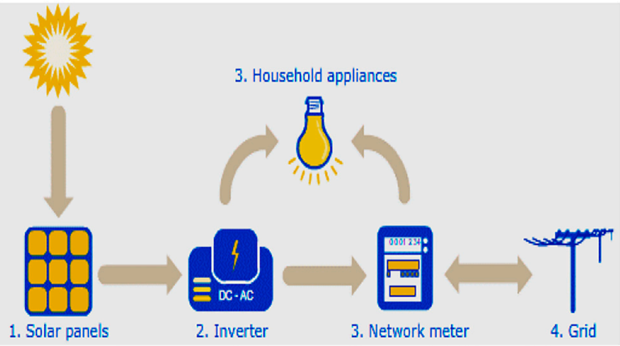

FIGURE 5 | Residential grid-tied solar Photovoltaic system diagram (Wikimedia Commons, 2018).

3.1.2 Photovoltaic System

Solar photovoltaic is the world's third-largest renewable energy source by installed capacity, after hydro and wind power. Solar panels transform the sun's solar radiation directly into useful electrical energy (**Figure 5**). California and the Agua Caliente Solar Project are the world's largest standalone PV generating installations. The aggregate capacity of both power plants is more than 250 MWP. However, due to the high cost of solar panels, its use is limited to less than 1% of total global energy production. PV energy arrangements are supposed to be unique of the most economical alternatives to encounter rural needs of energy.

For small communities of up to 100 homes, the economic feasibility has been built a hybrid PV system for decentralized power generation. The ideal mix can be determined using the hybrid PV system optimization approach based on the charge of energy produced, that is justified further by distance angle, tilt, and azimuth angle from the nearest power line. A PV hybrid system's performance is measured in terms of electricity generation dependability across a wide range of load circumstances. The load and insolation were calculated using statistical methods. The output power of a PV panel is calculated using the equation below.

$$E = A \times r \times H \times PR$$

Where E stands for energy that is in (kWh). r shows solar panel yield which is in (percent). A stands for total covered panel area (m^2).

PR stands for performance ratio, a constant for losses (ranges lies between 0.5 and 0.9, showing default value = 0.75). H stands for solar radiation yearly average on slanted panels, and r is the solar panel return, which is computed by dividing one solar panel's electrical power which is in kWp by its area.

3.1.3 Hydro System

Over the last four decades, global hydroelectric power output has gradually increased by an average of 3% every year. In 2011, hydropower from over 160 nations generated around 16% of global electricity. Water wheels are the forerunners of current turbines, which are used to transform hydraulic power into mechanical power, which is then converted into electrical power using a generator (Li, 2021). Hydroelectric power, unlike solar and wind power that is fluctuating and constantly changing, is subject to a protracted seasonal cycle. The flow of water in rivers and streams fluctuates slowly as the seasons change.

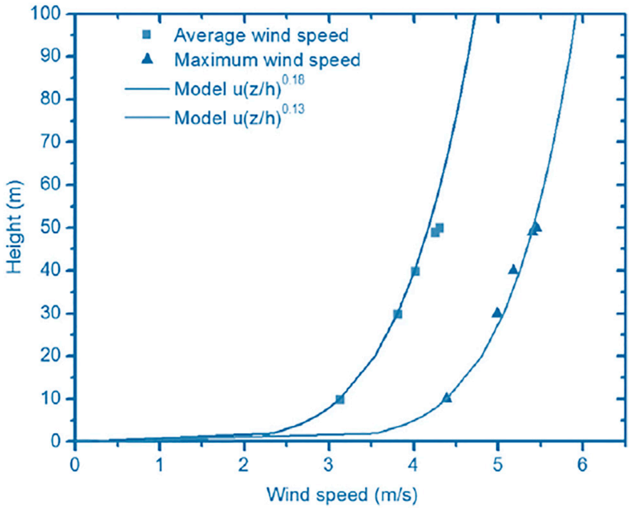

FIGURE 6 | Relation between Wind system and height (Liu and Janajreh, 2012).

3.1.4 Wind System

The area must have a high potential for wind energy throughout the year in order to operate a hybrid wind energy system successfully and affordably. Wind energy is currently captured utilizing a variety of small and large wind turbines of varying sizes and designs. It is one of the most rapidly increasing sources of alternative energy. It has a longer operational life than solar power and can generate electricity even on gloomy days and at night.

As a result, both wind and solar power systems require energy storage systems to store extra energy and use it when demand exceeds supply (Zhang and Toudert, 2018; Zheng et al., 2018; Motahhir et al., 2020). The reassuring option, on the other hand, is that people can produce enough energy to satisfy their regular needs by setting up small solar or wind farms. **Figure 6** shows the height to wind speed relation.

The generating capacity of a wind turbine is one of the most important factors to consider decisive criteria in selecting a certain kind of wind turbine for the chosen location is as an important component of a hybrid wind generators. Whenever feasible, turbine with best regular generating capacity recommended. A simplified technique for predicting yearly wind percentage was provided grounded based on the findings of an 8-year simulation using Wind statistics from five different places, hour by hour. Weibull wind speed distribution on a monthly basis data as input, other model factors such as the energy-to-load ratio, battery-to-load ratio, and others are used. Weibull devised the following equation to compute wind speed:

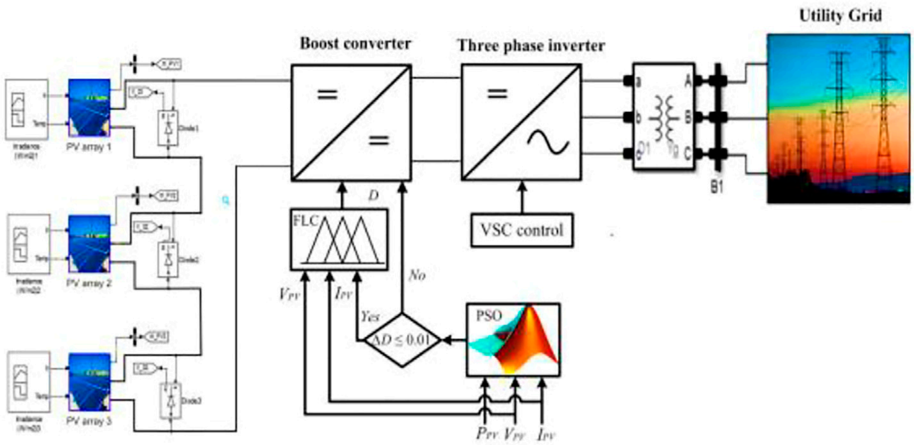

FIGURE 7 | PV based hybrid system MATLAB schematics (Gonzalez-Longatt, 2005).

$$f(v) = \beta\eta(v\eta)\beta - 1e - (v\eta)\beta$$

β = *shape factor* v = *wind speed.*

3.2 Optimization method for PV Based Grid System

The efficacy of grid-connected solar power is heavily dependent on the site's solar irradiation, ambient temperature, load demand, and other factors in geographic area of installation. Identifying the best location and size for solar PV installation is a critical answer for improving radial distribution system performance. The design of the PV system to interface artificial intelligence techniques are used in the radial distribution network necessitates power system network analysis and mathematical modeling. The load flow analysis is performed in MATLAB simulation as shown in **Figure 7** in conjunction with the SPSO to identify the placement and capacity of solar PV that will link to the Bahir Dar distribution network. By allowing for fluctuations in power demand over time, PV on-grid system integration is crucial for enhancing network capacity and system dependability. The utility grid is connected to an on-grid solar power system. The primary advantage of such a system is that electricity may be obtained from the utility grid, and when that power is unavailable, the PV system can step in. These on-grid systems might include or exclude battery storage. Batteries, a charge controller, solar modules, and inverters are used in these systems to improve the on-grid electrical system's stability and offer long-term utilities service for a wide range of loads Electronic converters with high power play an important role in connecting a solar system to the grid by converting DC to AC and power conditioning (Zakaria et al., 2020). A proposal is made for the current status of solar optimization study in a power system. This research looks on modeling approaches, restriction criteria, and optimization techniques. Because it is clean, ecologically friendly, and provides reliable power, the PV module system is full of potential. The effects of stand-alone and grid-installed solar generating on power system link, as well as their link to mandate answer, were researched. For calculating the location and size of solar generators, optimization approaches like as the genomic algorithm and swarm optimization were both introduced around the same time (Getie et al., 2020) used the evolutionary algorithm and a geographical information system to integrate solar power with radial feeders. The genetic algorithm which was used to approximate the magnitude and point of penetration, and geographical information is utilized as data to decide where to install solar panels. As the multi objective function for photovoltaic integration, this study solely analyses real power loss and voltage profile.

3.3 Optimization method for PV Based Stand Alone System

A stand-alone PV system should always be able to provide power to the load or energy consumption. The suggested technique, based on using hourly energy analysis, a curl (statistics) for battery bank (power, Wh), PV- array (space, m^2) proportions that satisfy the demand at all periods may be created. Since the solar power supply capacity varies, the battery store should be huge enough to provide enough power regardless of the number of cycles (discharge/charge) that the battery has to go concluded. This means that the solar grid will be backed up at sunset to meet the charging until more solar energy is available to start another charging cycle. Solar radiation, array size of PV, and storage volume are used to determine the efficiency of a PV system that is not connected to the grid. As a consequence, the scale of freestanding PV systems is essential to their dependability. Instinctive, analytical sizing methods and numerical are three types of sizing methods. Because it works with intuitive knowledge (without the use of cognitive processes), the first category of algorithms is highly imprecise and unreliable, and the risk of the end result being inaccurate is fairly high. The second is more precise, but accurate modeling requires series of solar radiation for a long term. There are ways in the third category that utilizes equations to describe the size of PV arrangement displaying as a result of dependability that is the focus of this study: boosting the output power of PV modules while lowering the system life cycle cost. Since most of the solar energy arrives in a straight line, solar panels or solar installations that point directly at the sun accumulate more energy by being perpendicular to the straight line between the panel and the sun. During the day, solar panels should face the earth's equator (southern northern hemisphere or northern southern hemisphere) to capture as much solar energy as possible. The challenges and limitations of autonomous solutions to optimize the size of photovoltaic installations are highlighted to solve the problems of inaccurate parameter assumptions and poor demand performance evaluation of photovoltaic systems, which often lead to high material and installation costs. Along the same route, a new adaptation method was also proposed to improve the ability of photovoltaic generators to provide power to remote areas with pumping storage. Their research results show that zero power outages can be achieved at low energy costs, but the system does not use all the solar energy available in the area. Photovoltaic systems analysis refers to the concept of daily battery status to improve reliability while minimizing the possibility of power outages, excess energy, and cost constraints. However, priority must be given to strict compliance with the load profile. Another optimization strategy involves three steps. The first step is to calculate the photovoltaic power generation capacity connected to the grid with the help of 1-year solar energy data. It is believed that peak sunlight, ambient temperature, and cable and dust losses will affect the output energy of photovoltaic networks.

The quantity of stored energy, PV array output energy, load energy demand, battery efficiency, and inverter efficiency are used to compute the daily status of the battery storage in the second stage. In the third step, the chance of load loss is assessed, and the system cost is approximated using the costs of the PV array, batteries, and other components (Lund and Mathiesen, 2009). On the other hand, the system cost equation is only partially derived and needs to be solved intuitively. The system simulation can be adapted to reduce the battery when the size of the solar photovoltaic device is not limited (very large). Since the solar photovoltaic device is huge, the system simulation can be repeated after determining the minimum battery size, but this time it is the smallest solar photovoltaic device. The size of the battery makes the battery sensitive to deep discharge when using this method and the size of the photovoltaic installation makes the system too large to be economically feasible. Therefore, the capacity of the battery pack can be increased, and each size can be simulated to find the smallest array. You can repeat this process to create a curve of the battery and PV array size pair, as shown in the results and discussion section. The accuracy of this method is determined by the simulation data, which includes both environmental parameters (such as sunlight exposure and ambient temperature) and loads. Therefore, hourly data obtained from reliable models such as those used in this study can guarantee availability and synchronization of exposure to solar radiation. To develop energy balances over time while taking into account real energy requirements for an energy efficient house as well as real radiation and ambient temperature data, a PV single system with dependencies on ambient temperature and other important factors was used in conjunction with inverter converter performance data. To ensure continuous functioning, the simulations first established a direct relationship between the area of the PV array and the capacity of the battery bank. One extreme of the connection is a high area of PV panels paired with a small battery capacity, resulting in low PV array effectiveness and a low battery consumption index. A small PV array, on the other hand, is the polar opposite. The tilt angle optimization approach was developed as a new optimization tool. Because of climatic and environmental conditions that fluctuate throughout the year, such as seasonal fluctuations, this optimization approach is focused at calculating effective tilt angles at various periods of the year. When compared to tracking systems, this strategy enhances collection efficiency while incurring no additional costs. Averaging the values of the solar geometry parameters for each mean solar day was used to do the calculations. The incident solar irradiances on a tilted surface, which include direct, diffuse, and reflected solar irradiances, may be expressed as a function of the global irradiance I on a horizontal surface by

$$ITI = (1 - IdI)cos\theta cos\theta z + IdI1 + cos\beta 2 + p1 - cos\beta 2$$

The notion of the optimal periodical inclination angle was used to carry out this optimization, which allows for maximum incidence on the panels while simultaneously maximizing the use of the household's actual energy usage. The inclination angle should be changed seven times per year, according to the computation of solar radiation for sloping surfaces using different solar geometry factors and incoming solar radiation, although total apparent power overestimates the load demand by 18%. On the other hand, these adjustments result in higher panel output and PV station reliability. The analysis of random load fluctuation demonstrates that the load profile must be followed notwithstanding the constraints. A power shortfall in the plant might occur from even slight increases in load demand.

3.3.1 Utilization of Solar Photovoltaic Energy

Photovoltaic systems power entire towns in distant places of the world. In the United States and Europe, a few utility companies operate "solar farms" to generate power (Majidi et al., 2017). Photovoltaic cells have other industrial applications as well. These are often low-power applications in regions where regular electricity sources are cumbersome. Some emergency roadside phones use solar cells to charge their batteries. Some of the common applications are listed below.

3.3.2 Duffel Bags

The thin-film solar panels mounted on the outside of the backpack generate up to 4 W of power, which is enough to charge mobile phones, cameras and other electrical appliances while walking. External solar cells can also be added to briefcases and handbags. Students, hikers, and campers who need to keep their electronics charged while travelling or when they arrive at their destination would appreciate these backpacks.

3.3.3 Paint

Rather of utilizing standard silicon solar cells, polymers soaked in a solvent form “paint” or coat that may be put to any surface, include buildings, workplaces, and vehicles. It is low-cost and versatile. Instead of bulky solar photovoltaic panels, a solar paint employs thin-film nanoparticles as solar conductors rather than silicon. When small solar cells are placed to the surfaces of structure which confront the sun, they silently create pure, green power.

3.3.4 Solar Transportation

Photovoltaic (PV)-powered transportation is a novel technique to make the most of the sun’s energy. Solar energy can be used to power trains, subways, buses, airplanes, vehicles and even roads, and solar transportation is rapidly becoming a leading choice for renewable energy. A solar-powered aircraft has just completed a round-the-world voyage over the Pacific Ocean, capturing huge waves in unforgettable images. On the other hand, solar buses are helping China reduce its carbon footprint while ensuring efficient public transportation in densely populated areas such as Beijing. In the end, solar cars began to appear in racing competitions around the world, especially in Australia, where the solar spirit model aroused great interest. With these and other improvements, there is no doubt that solar energy is transforming the global transportation sector.

3.3.5 Refrigerators for Vaccines

As the entire world is experiencing the effects of the Corona Virus. Vaccine refrigerators are now required in all hospitals and clinics. There is no guarantee of 24-h electricity in developing countries, there is often no electrical infrastructure. Solar-powered vaccination coolers have been developed by private companies for use by healthcare workers in rural areas may provide crucial medication to individuals in need, according to Charlie Gay, Office of Energy Efficiency and Renewable Energy, Solar Energy Technologies Office. This technical solution has been saving lives for more than four decades.

3.3.6 Cell Phone Charger

After a few hours of ultraviolet radiation, the mobile phone USB charger can fully charge the mobile phone. These tablet-sized solar panels can power GPS trackers, tablets and even computers. They can be attached to backpacks and used to extract solar energy while walking, making them ideal for leisure activities (Ming et al., 2017).

3.3.7 Solar Textile

Solar garments are a sort of solar textile that can be used for a variety of purposes. To generate useable solar power, solar cells are weaved into textile strands. According to Hicks, one variation, developed with faster than light (FTL) Solar, might remain erected like a camp to supply both electricity and shelter. Considering military service, safety missions, respite efforts, leisure activities, medical centers, and even makeshift housing as options. Solar fabric is the ideal answer for everywhere that need flexible and convenient solar power. According to Gay, roofs are one of hundreds of places somewhere solar panels create energy. We expect to see many more sites where solar technology is used to offer unconstrained, low-cost electricity as costs decrease and energy output rises.

3.3.8 Solar Water Pumps

Solar water pumps are used to promote water for irrigation, gardening, household use, drinking and other related purposes. These devices are suitable for areas where there is no electricity or limited power supply. The precisely crafted modules of the system are impact resistant and can withstand harsh weather conditions such as storms, rain, and dust.

3.3.9 Solar Tents

The solar tent is just a larger solar backpack. The built-in photovoltaic cells in the tent store solar energy throughout the day and are then used to illuminate the tent at night, as well as small electrical appliances such as charging or power electronics and radiators. The United States military uses a variant that can generate up to 2 kW of electricity during day.

3.3.10 Solar Buildings Technologies

Passive cooling and heating systems rely on the building’s design to satisfy specified thermal demand objectives with little or no mechanical support. Active heating systems use mechanical aid to provide hot water for space heating, while passive heating and cooling systems rely on the building’s architecture to satisfy set thermal demand objectives. Solar building technique is widely used in Pakistan (Li and Zheng, 2019). However, there are no construction laws in place in the country that allow solar building systems installation.

3.3.11 Street Lights

Solar energy is increasingly being used to power streetlights around the world. The sun charges the batteries throughout the day, which power the light-emitting diodes (LEDs) that illuminate the streets at night. Smart sensors are being installed in streetlights in San Diego, which might direct motorists to open parking spots and assist first responders in an emergency. The combination of internet-connected sensors and solar-powered lamps saves both time and money (Indra Gandhi et al., 2018).

3.3.12 Solar Ovens

Solar ovens, sometimes called solar cookers, use the sun’s energy to prepare food. Solar cookers either are parabolic or square shapes covered with a reflecting substance that focuses the amount of solar radiation into the box, warming the food equally. To assist focus the sun’s beams, the top lid is commonly made of glass. They are healthy to live with and are commonly employed in developing countries to reduce air pollution produced by fuel burning.

3.4 Optimization Issues

Solar energy confronts significant obstacles that might stymie its rapid expansion. These impediments can be characterized in terms of technology, politics, economics, and dependability. The adjustment of these issues, on the other hand, reduces the drawbacks and improves the solar energy system's reliability. As a result, greater solar energy optimization can help to alleviate production uncertainty. PV power technology is being heavily invested in to improve efficiency and economic feasibility.

3.4.1 Extra Investment

Inverters and storage batteries must be purchased separately from PV cells. For use on the power grid, inverters convert direct current to alternating current. Storage batteries are important in on-grid connections for giving continuous power of electric power. On the other side, this higher spending could provide a solution to the PV cells' intermittent problems (Dong et al., 2019).

3.4.2 Issues With Intermittency

Solar energy and photovoltaic cells, like all other renewable energy sources, are prone to outages. It implies that it is not always available for power conversion, such as at night or when the weather is gloomy or damp. As a result, PV cells are unlikely to meet all of an electric power system's demands.

3.4.3 Easily Broken

Solar PV has no upkeep or operating costs, it is vulnerable to damage due to its fragility. To protect your investment, there is a solution in the form of additional insurance.

3.4.4 Expensive

PV system market costs remain exorbitant and beyond of reach for many households. The higher production costs of non-conventional energy sources, combined with the availability of cheaper fossil fuel alternatives, entice customers and generate market rivalry for non-renewable technology (Lagouir et al., 2019). The lack of economic models to support renewable energy technology prohibits small-scale PV systems from being scaled up to large-scale or commercial facilities. Subsidies are distributed more effectively to traditional fuel sources, giving them an unfair advantage over nonconventional sources. Governments must stimulate the market for PV technologies in order to reap the most advantage from renewable applications in the government market, government-driven market, and loan and cash market. PV plant input requirements, like as land and water, impede the installation of PV capacity.

3.4.5 Low Productivity Level in Future

In the near future, the technology will face another severe threat when the panels put during the early stages of the energy boom reach the end of their anticipated lifetime and are finally thrown in landfills. When the life duration of these panels reaches roughly 25 years, as indicated by the manufacturer, their productivity begins to decline. Recycling solar panels is a logical alternative for addressing the predicted worldwide PV waste, since retired PV panels may be reconditioned and redeployed. Recycling not only provides an effective method of recovering valuable elements from solar waste, but it also contributes to a better environment by using less energy to recover raw materials. The research and development work concerning solar PV recycling has already begun in countries such as Japan, the United States, India, Australia, and Europe.

3.4.6 Lack of Trained Professionals

The scarcity of trained personnel to teach, operate, and maintain non-conventional energy infrastructure, particularly in rural regions, has a detrimental impact on people's desire to adopt these technologies. Geographic location is also important, because PV systems are only practical in certain places, and they face competition from alternative technologies that are better suited to the specific topography. Adopters are often concerned about systems failing during the rainy season and avoid purchasing PV systems owing to a lack of understanding. The absence of information between the supply and adopter sides further impedes the technology's uptake. Because the generation and consuming sites are far apart, poor grid connection raises transportation costs and transmission losses. As a result, the majority of investors are hesitant to invest in technology.

3.4.7 Environmental Disadvantages

Due to various preliminary case studies, there is little understanding of the environmental and economic advantages of PV recycling technology. Although element recovery is advantageous, the energy required to collect valuable metals from discarded PV panels is greater than that required to gather, dismantle, and retrieve the modules. Although recycling operations are not viable, the cost of recycling PV panels is minimal (Maulik and Das, 2018) According to research, the profit earned from selling the recycled material of copper indium gallium selenite solar panels (CIGS) is greater than the recovery price. However, the earned amount for c-Si and p-Si solar modules is less than the cost of solar panels. Despite the financial benefits of reselling recovered items and the environmental benefits of recycling, businesses prefer landfill disposal to recycling due to the lower initial cost of dumping.

4 OPTIMIZATION CHALLENGES

Table 4 shows the summary of different approaches which are used for optimization techniques and method. Non-conventional energy sources have been an important aspect of study and development among scholars since the early 20th century. Despite the remarkable technologies that have evolved in recent decades, the majority of developing countries have delayed the shift to renewable energy sources. Fossil fuels have boosted CO_2 emissions and contributed to global warming. Because of numerous types of hurdles, the majority of nations have exhibited reluctance to adopt renewable technologies. Based on the existing market, policy implementation is critical, which includes energy auctions, integration of PV technologies with non-conventional energy sources, and timely completion of PV projects. By allowing users to purchase or lease a portion of the

TABLE 4 | Summary of approach optimization technique and methods (Li et al., 2016).

	Approach		Problem		Optimization methods and techniques	Recommended
	MO	PF	UC	DN		Method/Technique
8	4	4	8	8	Mimetic Algorithm (MA), Improved Mimetic Algorithm (IMA)	IMA
8	4	4	8	8	Multi-objective Particle Swarm Optimization (MOPSO), PID for converter, PI and Fuzzy Logic Controller (FLC) for battery charging/discharging	MOPSO for converter FLC for battery
4	8	4	8	8	Centralized and decentralized OPF using Kriging model of power electronic transformer (PET)	A decentralized approach using PET
4	8	4	8	8	FLC for load management	FLC
8	4	4	8	8	FLC using MOPSO, Multi-Objective Genetic Algorithm (MOGA)	MOGA
4	8	4	8	8	Stochastic model, solved using scenario reduction (SR) and Benders decomposition (BD)	SAME
4	8	4	8	8	DPR using interior point method (IP)	SAME
4	8	4	8	8	AC/DC OPF using IP, UPF algorithm	AC/DC OPF using IP
4	8	4	8	8	Expectation programming model, chaotic particle swarm optimization algorithm (CPSO), TOU, spot price method	Spot Price Method
8	4	4	8	8	Probabilistic model using Monte Carlo (MC) and SR	SAME
4	8	4	8	8	Conventional ac grid, hybrid AC/DC micro grid, plug-in hybrid electric vehicles (PHEV) load optimal power flow with GAMS software	MILP
4	8	4	8	8	Compartmentalization strategy, nan grids solved with pinning synchronization technique for optimal power flow	SAME
4	8	4	8	8	Sub micro grids solved with multilayer and multi follower game theory-based optimization model for optimal power balance of 3 phase hybrid micro grid	SAME
8	4	4	8	4	Use of HOMER software to reduce the cost of energy and environmental emissions from hybrid micro grid for the designated load	SAME
8	4	4	8	4	Reducing the cost of energy and environmental emissions using Particle Swarm Optimization PSO	PSO

shared PV system, community-shared solar projects aid in the creation of financial arrangements and the alleviation of financial constraints. These business models, in turn, contribute to the development of a PV system in the residential market, the stabilization of power prices, and the reduction of power bills. To reap the full benefits of an energy transition, policies must be strengthened through mobilizing financial investment, economic diversification, and information exchange. PV system market costs remain exorbitant and beyond of reach for many households. The lack of economic models to support renewable energy technology prohibits small-scale PV systems from being scaled up to large-scale or commercial facilities.

4.1 RES Optimization Challenges

To enhance efficiency, there is a significant investment in renewable energy technologies. The cost of producing renewable energy continues to plummet in 2017, according to an IRENA (2018). The development and deployment of renewable energy technologies necessitate policies and expenditures that have not been thoroughly assessed. As a result, power quality is a metric that assesses a system's capacity to offer users with continuous access to their electronic devices. Any irregularity or breakdown in the power grid that obstructs or interrupts electrical equipment's operation indicates a lack of power quality or reliability. Renewable energy sources will save costs in both transmission and production. The most prevalent disadvantage of employing RESs is that they represent a constant challenge because to their fluctuating existence, which is entirely dependent on climate fluctuation and may result in load refusal in some places (Maulik and Das, 2018). The power production of RESs has substantially grown as a consequence of the deployment of various optimization technologies in response to growing energy demand and improved performance. The entire power producing capacity has increased by about 9% since 2016 (Zakaria et al., 2020). According to the reference, renewable energy accounted for 70% of net additions to global power capacity in 2017 (Raturi, 2019). The key causes for this were the improved cost competitiveness of solar PV panels and wind turbine technology, as well as the availability of performance optimization technologies. Furthermore, the increased usage of renewable energy raises awareness of the need of energy efficiency and quality in power generation and distribution. The biggest disadvantage of adopting renewable resources is that they are intermittent nonetheless, one of the key advantages is the system reliability demonstrated by the operational parameters. Power generated from renewable sources will soon be less expensive than electricity generated from fossil fuels. General, the development of RESs has resolved various difficulties-optimization-in reducing energy costs, reducing costs, net and other optimizations related to costs, such as reducing life cycle costs

(LCC). The optimal size and capacity of the trees is determined by providing the required reliability in terms of power supply, operating costs, and grid power and greenhouse gas emissions.

4.2 Energy Optimization Challenges

The uncertainty of how much of the sun's rays it will get is an issue for solar PV because the weather might change at any time. As a result, determining how much energy to store for future use would be challenging. While power is still required, sunlight is rare during the night. Solar energy has significant obstacles that might limit its fast expansion. Technology, politics, economics, and reliability are the four areas that these hurdles fall into. On the other side, addressing these problems decreases the disadvantages and improves the solar energy system's dependability. The researchers are also given information on the most recent developments in intelligent optimization in solar energy applications, as well as important research topics. Since the goal of optimization is to maximize benefits while reducing costs, it is critical to understand the advantages and disadvantages of the systems under consideration. In this setting, academics have begun to explore and propose strategies and models to maximize advantages while minimizing drawbacks. To overcome difficulties related to the design, operation, and process of renewable systems, several researches combine traditional optimization techniques with newer heuristic approaches (Zhao T. et al., 2017; Zhao Zy. et al., 2017; Allam et al., 2018; Eajal et al., 2017). PV systems require precise and reliable performance data in order to precisely assess power output and capacity in current operating circumstances. The formulation of effective operational and control choices is aided by this dependable data. On the other hand, by examining the numerous aspects that impact performance and exploring potential ways to increase the power plant's performance, the optimization and efficiency of a solar system may be improved. PV cells have a number of problems, including a halt in power output when the panel is not exposed to sunlight and a poor efficiency. This might result in the system's original investment criteria not being met. As a result, solar energy storage devices have been proposed as a means of compensating for the lack of light and smoothing out power output. This technology is dependent on batteries, which are frequently bulky, huge, and heavy, take up a lot of space, and require maintenance or even replacement on a regular basis (Li et al., 2016).

5 CONCLUSION

For policymakers all throughout the world, this document presented an in-depth review and relative analysis of solar technology for clean power generation.

According to the research results, there are two types of technologies: complex technologies, such as PTC, PV and STP, with a total installed capacity of 7,828.5 MW and an efficiency of 10–16%, LCEO is $0.1–0.24/kwh, which has broad prospects in terms of environmental impact and technical efficiency. There are also technologies that, although having a 390 MW installed capacity, look to be promising in terms of environmental implications and technological efficiency. Furthermore, CPVT and CPV, they have yet to be utilized in large-scale power facilities since they are still in the early stages of development. Nonetheless, Scientists from several nations are leading the charge in CPV and CPVT research. The use of solar energy to improve energy efficiency has been a concern due to the dynamic nature of solar energy, solar PV material, design, and challenging computation of optimization difficulties. As a result, this review looks into solar energy optimization in depth. The optimization techniques have shown excellent results in solar PV applications in terms of size, power production and capacity demand. Additionally, the enhancements to reduce operational expenses and power damages while also increasing peak power integration and controllability. The paper also looked at the primary roadblocks to solar PV optimization, emphasizing the importance of modern computers and objective function (Qiu et al., 2019).

AUTHOR CONTRIBUTIONS

AS, and AH, suggested the idea of this work, wrote the manuscript and made final improvement, whereas SC and PM provided help with alignment of the paper, proof reading, editing, improvement of the article. AI and MM provided the financial assistance.

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GLOSSARY

FPC Flat plate collector

CPV Concentrated photovoltaic

GaAs Gallium Arsenide

CPC Compound parabolic collector

GIS Geographic information system

HCPV High Concentrated photovoltaic

MWh Megawatt hour

LCPV Low Concentrated photovoltaic

CIGS Copper indium gallium selenide solar cells

LFR Linear Fresnel reflector

IEA International Energy Agency

HTF Heat transfer fluid

HFC Heliostat Field Collector

CdTe Cadmium telluride

BESS Battery Energy Storage System

MHP Micro hydropower

CSP Concentrated solar power

PTSTPP Parabolic Trough Solar Thermal Power Plant

PV Photovoltaic

ANN Artificial neural network

PVT Photovoltaic thermal collectors

CPVT Concentrated photovoltaic thermal collectors

SAM Solar advisor model

SBS Spectral beam splitting

SCR Solar Central Receiver

SGS Steam Generation System

TES Thermal energy storage

LCOE Levelized cost of electricity ($/kWh)

NREL National renewable energy laboratory

STP Standard temperature and pressure

PDC Parabolic dish collector