

Assessment of PV solar energy system and smart grid: a review

Abstract

Energy is key source of the whole procedure of advancement, development and survival of every living being and it assumes a basic part in the financial improvement and human wellbeing of the nation. An extremely quality energy arranging is important to deliver the issue identified with supply request, energy neediness and barometrical impacts of vitality development. This activity is relied upon to help comprehend the dynamic idea of the sunlight based energy directions and related issues and furthermore make a stage to share data on appropriate issues. The purpose of this paper is to present an updated overview of PV solar energy system, in addition to assess the growth space and concept of smart grid in the post statute era by considering the domestic conditions, technology development and native industries related to solar energy.

Keywords: solar energy, smart grid, structural design

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Introduction

Presently a day's sun oriented energy structure is the new patterns of age of power as non-ordinary energy framework. This article presents part of sun based energy framework in clean advancement component and improvement of keen city in India. It is a charming spot for creates power by sun based energy framework since India is thickly populated and has high sunlight based radiation. India's hypothetical sun based power gathering, on just its territory range is around 5000(PWh/year). The everyday normal sun oriented radiation occurrence over India shifts from 4 to 7KWh/m² with around 1500-2000 sun sparkle hours for each year. In year 2009, India talks to a 19 billion US dollar intend to deliver 20 GW of sun oriented power by 2020. The measure of sun based energy created in India in 2007 was under 1% of the aggregate energy request. The lattice intelligent sunlight based power as of December 2010 was only 10MW. Government subsidized solar energy in India represented roughly 6.4 MW/Year of energy starting at 2005, 25.1 MW was included 2010 and 468MW of every 2011. By July 2012 the introduced framework associated PV had expanded to 1040.67MW and India hopes to introduce an extra 10,000MW by 2017 and an aggregate of 20,000MW by 2022.

The measure of land required for sun arranged power plants— at display approximately per km² for each 20– 60 megawatts (MW) created. The designing more suitable for a vast bit of India would be an exceedingly spread game plan of individual roof control age systems, all related by methods for a close-by organize. As demonstrated by a 2011 report by BRIDGE TO INDIA and GTM Research, India is go up against a perfect whirlwind of components that will drive sun based photo voltaic (PV) gathering at an “irate pace all through the accompanying five years and past”. The falling expenses of PV sheets, for the most part from China yet moreover from the U.S., have blended with the creating cost of cross section control in India. Government support and plenteous sun fueled resources have moreover extended sun based allocation, however perhaps the best factor has been require India, “as a creating economy with a surging common laborer,

is by and by going up against a real power insufficiency that often continues running in the region of 10 and 13 percent of consistently needs. The organization of India is propelled the usage of sun fueled vitality through various frameworks. In the latest spending get ready for 2010/11, the organization has revealed an assignment of 10 billion (US\$189 million) towards the Jawaharlal Nehru National Solar Mission and the establishment of a spotless vitality bolster. It is a development of 3.8 billion (US\$71.8 million) from the past spending design. This new spending arrangement has in like manner engaged private sun controlled associations by reducing conventions commitment on daylight based sheets by 5% and exempting remove commitment on sun based photo voltaic sheets.

Sun oriented energy assumes essential part being developed of keen city in light of the fact that close terrestrial system is the portion of clean advancement instrument. The Smart City rules demands 10% of the Smart City's energy necessity to originate from sun based energy framework and at introduce time in India imports about 80% of its raw petroleum utilization, 15% of its coal utilization and 35% of its gaseous petrol utilization which is identified with ordinary energy source and 75% of Greenhouse gas outflows are created in Cities and diverse Communities. In our research work depth assessment of performance, prediction, and investigation of solar energy system is to be done using different assessment procedures. The works on macro level include a case of Nasik, India considered as a study area and modeling of standalone 10KW solar energy system by HOMER software and reliability assessment is done by fault tree analysis

Modeling of solar energy system

Solar energy plays a vital role in the current energy scenario. Non-conventional energy sources are a better candidate that can overcome the problems of the gradual depletion of fossil fuels as well as the global warming caused by the green house gas emission. Due to the forever and clean nature of renewable energies, they received immense interest and the application of renewable energy had been accelerated in the regulatory past few years (Table 1).¹⁻⁴

Table 1 Area wise hybrid system component

Author (s)	System component	Evaluation area	Load details	Sizing approach	Sizing results
Kalantar ¹	Wind Turbine(WT), Photo-Voltaic (PV),& Battery	Tehran, Iran	225KW Peak, 25KW Base	Genetic Algorithm (GA)	195 KW WT,85KW PV 230 KW Microturbine, 2.14 KAh Battery
Yang ²	WT,PV, Microturbine & Battery	Dala Jia Island, China	1.5KW Constant	GA	6KW WT, 12.8 KW PV,6KAh Battery
Bounbum roong ³	WT, PV, Diesel & Battery	Chik Island, Thailand	26KW Peak, 5 KW Base	Particle Swarm Optimization((PSO)	15 KW WT,24 KW PV,50 KW Diesel,151 KWh Battery
Vikas ⁴	Solar, wind	Sagar, India	1.5kw	Homer	3KW Solar, 6kw wind

Energy examination of sun powered visually impaired framework idea utilizing energy framework demonstrating. By considering the sun based visually impaired framework worked at 18°C as the set point temperature, the cooling request in the nursery can be practically secured absolutely, which is the primary point of this idea. Nonetheless, the electrical request is decreased nearly by 73%. Furthermore, by applying the sun based visually impaired framework idea, the illumination level inside the nursery kept in the ideal level that

prompts more uniform development amid the entire year.⁵ Modeling and trial research of cross breed PV-thermoelectric framework for high thought sun based energy change. The essential relentless state limited component displaying shows the commitment of the TEC-TEG Module, blowing up the general productivity of the cross breed framework for high sunlight based concentrated illumination; the test and recreation comes about are coordinated (Figure 1).

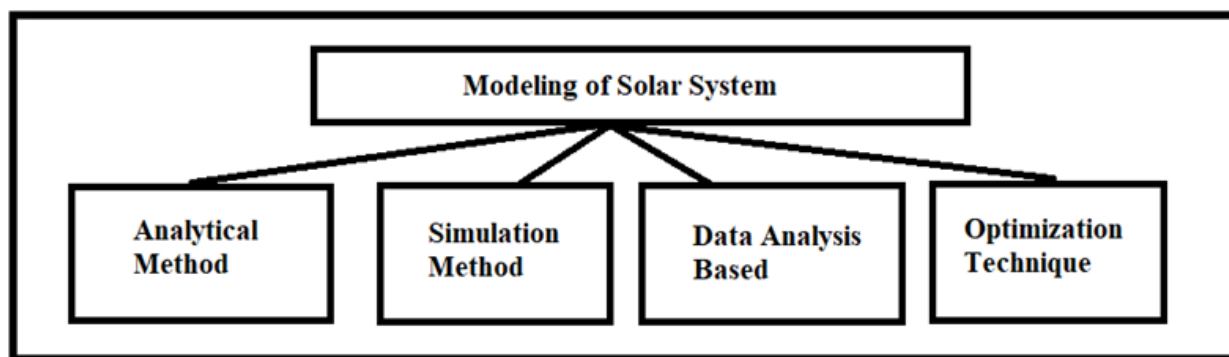


Figure 1 Modeling of solar energy system.

All of which brings out another framework that contemplates the PV electric power age, without bargaining the cooling potential and the quick electric creation of the thermoelectric gadgets.⁶ Displaying and estimating of consolidated power device warm close planetary system for energy age.⁷ Factual displaying of sun oriented breeze HRES in view of yearly cost, battery self-sufficiency work, measuring criteria and biological factual factor. Well ordered advancement hone is utilized to discover the proficient aftereffect of the sun powered breeze HRES display.⁸ After this⁹ created sun powered breeze half breed framework show in light of long haul reproduction. This framework coordinates diesel creating sets with the sustainable power source. Further,¹⁰ calculated model of HRES has assessed fuel and energy sparing and announced the issue identified with the misuse of joined inexhaustible and traditional energy sources. An extraordinary

element of calculated model is that a supplementary divisive source is acquainted all together with acquire the power electric adjust at the busbar amid the reproduction organize and also not well measured parts assuming any (Figure 2).

Loss of energy supply likelihood (LPSP) to created coordinated sustainable power source framework display. In view of load appropriation, the likelihood thickness capacity of the capacity is acquired and therefore the battery measure is computed to give the pertinent level of the framework firm quality utilizing the LPSP system.¹¹ A measurable model of at least one PV exhibits are joined with diesel or potentially twist for influencing a more steady power to supply. The MATLAB program permits finding a close perfect size of framework’s part and foreseeing the framework’s execution.¹² The

Hybrid structure is mulled over from the view motivation behind at this very moment consistency as transient relentless and temperamental case. Haque et al.¹³ looked into the most reasonable setup of a cream vitality system for a regular electric-warmed home in St. John's, Newfoundland. It makes the feeling that multi-port DC-DC converter is legitimate for the pined for cream vitality system.¹³ Encourage¹⁴ made showing of hybrid vitality structure for off system charge of a social affair of towns and drove costs can be restricted through proper part estimating and stack organizing. The model is made with the objective of constraining cost work in perspective of intrigue and potential impediment. The model had been streamlined using LINDO s/w 6.10 variations. In light of the hydrogen vitality unit¹⁵ made show with the mix of wind-PV-vitality unit. For the creation and uniform

supply of hydrogen for vitality unit, an electrolyzer and a reformer are similarly considered in the proposed system. Assist in the field of close planetary system¹⁶ made showing of free hybrid PV-wind structure. In that paper a discrete cost work is described and enhanced to choose perfect arrangement elective with slightest number of PV and wind units prepared for dealing with the yearly demand stack. System pantomime and vitality alter computation over a period of 3 years are used to compensate for diagram botch caused by the discrete thought of the perfect approach. a perfect hybrid vitality structure depiction for remote common district control age and updated HRES model of a remote scope of Jaunpur piece Uttaranchal region of India. The HRES includes wind, sun based, biomass and little scaled down scale cross breed to supply steady vitality to the pile.¹⁷

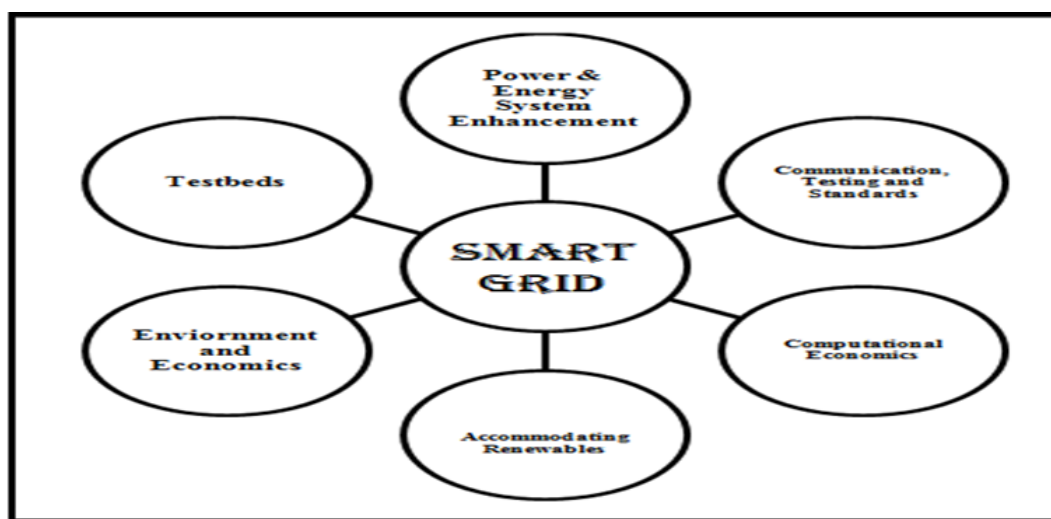


Figure 2 Assessment of smart grid.

Assessment of solar system under certain condition

Solar energy possibilities in deliberately found urban communities in Nigeria. The sunlight based assets are displayed utilizing manufactured hourly meteorological information for an entire year in commonplace meteorological year arrange. On a yearly premise, Kano has the biggest normal day by day worldwide level assets (6.08kWh/m²), while these assets are essentially equivalent for Onitsha (4.43kWh/m²) and Lagos (4.42kWh/m²). For double pivot following, which expands usage of sun oriented assets, the month to month scope of day by day normal sun powered insolation for all areas shifts between 3.65kWh/m² and 8.00kWh/m². An independent photovoltaic framework on a tilted surface is estimated to take care of a delegate family demand in light of natural and numerical renovation measuring philosophies. These measuring philosophies are general and can be connected to any area.¹⁸ Further¹⁹ explained Techno-monetary plausibility investigation of a sun powered biomass off network framework for the charge of remote provincial ranges in Pakistan utilizing HOMER programming. The principle motivation behind this investigation was to propose a practical and streamlined outline for power age utilizing half sort energy source PV/Biomass for a rural homestead and a private group focused in a little town of region Layyah in the Punjab territory of Pakistan. The electric load information was gathered for the water system and private needs. Half and half Optimization Model for Electric Renewable (HOMER) was utilized to outline and perform techno-financial investigation to meet the heap prerequisites utilizing PV/biomass crossover design. The sun

oriented irradiance information and the accessible biomass potential on the homestead was utilized as a part of the HOMER programming to play out the investigation. Add up to net present cost (NPC) and cost of power (COE) were gotten as an answer by the HOMER examination and afterward these outcomes were refined further by performing affectability investigation. Evaluating the capability of half breed PV-Wind frameworks to cover open offices stacks under various Moroccan atmosphere conditions. In this article, the pre-possibility of a PV-Wind Hybrid Microgrid System (PWHMS) is done to foresee a more practical design to have the capacity to cover the foundation of a run of the mill city with energy utilization of 4874kWh/month. In this way, a half breed framework is assessed in various climatic districts of Morocco keeping in mind the end goal to exhibit to what degree a geological site influences the measuring result in a Moroccan setting. In like manner, techno-financial improvement was made by Homer-genius programming, in light of the net present cost (NPC) for a venture life of 25 years.²⁰ Techno-monetary assessment of network associated PV framework for families with bolster in levy and day time duty direction in New Delhi. HOMER has been utilized to do the techno-financial assessment of network associated photovoltaic (PV) framework. The reproduction shows that the cost of energy (COE) and net present cost (NPC) move toward becoming 0 at around 1.8kW and 3.4kW for low and center section family unit. Additionally, high piece request family units required vast framework and more prominent funding to acquire compelling outcomes. The outcomes plainly distinguish that nourish in duty/net metering and time of day (ToD) tax direction are significantly affect on low and

center section family units as opposed to high piece families.²¹ Further,²² prefeasibility investigation as far as logical, biological and financial examination of a breeze sun powered HRES with water accumulation highlights for urban elevated structure application. Financial examination demonstrates that assembling and conservation expenses of the framework are encased in the life expectancy of the framework. The game plan illuminates or mitigates a few damages of frameworks, for example, security, visual effect, clamor contamination and reaction to the breeze. Speaks to pre-practicality investigation of sun powered breeze crossover framework’s forthcoming in a complex uneven territory. This prefeasibility ponder is completed to evaluate the potential for a sun based breeze half and half framework for Hamirpur town situated in western Himalayan Pradesh.²³ Investigate

GIS based site combination strategy for sun based breeze HRES for the western turkey. In this paper Fuzzy rationale and geographic data framework instrument are utilized to seek best and option area in the investigation zone regarding money related and environmental criteria.²⁴ Introduced a far reaching achievability study and techno-financial evaluation of a remote sun powered breeze cross breed energy framework with battery energy stockpiling for a detached island. All the above paper demonstrates that atmosphere condition is more imperative criteria of prefeasibility examination. Plausibility of sun powered breeze half and half sustainable power source framework essentially relies upon sun based radiation and wind energy potential accessible at the particular area (Table 2).²⁵⁻²⁹

Table 2 Different optimization techniques used in smart grid

Author	Objective	Technique	Outcomes
Verma ²⁶	Generator coherency determination in a smart grid	Artificial neural network	The significance of the proposed strategy is exhibited by general exactness of the test result for obscure example for IEEE-39 transport new England framework
Marzband ²⁷	Ideal energy administration framework for islanded microgrids	Artificial Bee colony	Artificial neural network with Markov chain method is used to forecast non send out power generation & considerations of load demand uncertainties
Rastgoo ²⁸	Routing protocol for smart grid	Neuro-fuzzy	This method is suitable for distributed real time computation and it also reduce cost & error of this network
Bahrani ²⁹	Thermal generating unit in smart grid	Orthogonal particle swarm optimization	Orthogonal calculation needs to capacity to tackle such complex issue including financial dispatch and it altogether enhances the PSO as far as high arrangement quality, heartiness and merging

Structural design of smart grid

The fundamental importance of building is the strategy of Components, their associations, and the models and standards speaking to their arrangement and advancement after some time. Building of splendid grid gives the compromise imperative to join the full vision of the arranged structure and it recognize key ranges and space interfaces and moreover perceive and administer how legacy systems should be composed. Configuration is vital to ensure a base level of satisfaction in structure necessities including the structures and framework organization, security organization, applications change and traceability requirements to recognized accomplice needs. Designing and showing parts of broad locale brilliant matrix and this sort of brilliant matrix is extraordinarily stunning game plan the extent that procedure, bolster, control, imperativeness organization, condition, and unflinching quality evaluation and assess the piece of supervisory control and data securing imperativeness organization structure, which is give better control respond likewise system. Other than the coherent, current, mechanical perspectives and perceives components of the direct and non straight control plot use for the refined wide region control are in like manner quantitatively analyzed.³⁰ In the wake of starting designing arrangement of sharp cross section³¹ perceives challenges with in the cross utilitarian blueprint of the brilliant lattice grid and the status of clever system related machine to machine correspondence structure setup is depicted and proposals are obliged assembled new and inventive parts. Executed secure and creative plan for last mile correspondence in information development based power grid system. A protected

correspondence building and arrangement has been duplicated which focus on secure data transmission and scattering between the brilliant meters at the store end and at the utility core interest. Transmission and course data respectability is done by Hybrid Encryption counts help nature of the model has been checked Figure 3 shows structural plan of shrewd network (Table 3).³²

Smart grid assessment under certain condition

A smart grid is describes by the bidirectional connection of energy and information flows, resulting in power saving and increasing system reliability and operation precision. The main aims of the smart grid are mitigating environmental and economic issues caused by the conventional fossil-fueled generation. The drivers of brilliant framework improvement of Europe can be credited to three perspectives: market, security and power quality, condition. The regard for the significance of ecological security and the developing difficulties of the sustainable power source interconnection, makes the European shrewd network gives careful consideration to the interconnection of the inexhaustible and disseminated age, dependability, control quality and the esteem added administrations of framework to all clients. The objective of the European shrewd network is building up a low-carbon vitality framework, by expanding the interconnection proportion of the sustainable and dispersed age, and accomplishing the reason for the vitality sparing by the request side administration. The shrewd lattice proposed by Europe goes for guaranteeing power supply feasible, monetary, and security, by the utilization of the inventive items and administrations, clever observing,

control, interchanges, self-mending advances. The similarity of the operation and activity of the age side, the traditions and the individuals who have both the attributes of energy suppliers and customers, would be come to. In light of the above portrayal of the brilliant lattice, the European Network of Transmission System Operators (ENTSO)

and the European Network Distribution System Operators (EDSO) distributed a shrewd framework benefits evaluation framework, which partitions the advantages into nine sections. The appraisal framework contains twenty one key markers. By getting to the markers we can evaluate the advantages of the keen lattice development (Figure 4).

Table 3 Comparison between today's grid and smart grid

Principle characteristics	Today's grid	Smart grid
Framework	Solid state & Electromechanical	Digital/Microprocessor
Communication Path	One path & Two path	worldwide integrated two way communicqué
Consumer Behavior	Consumers are uninformed & non-participate	Informed, involved & active consumer
Self heals	Responds to prevent further damage	Automatically detects & respond
Resists Attack	Vulnerable to natural disaster	Rapid restoration capability
Enables Market	Limited wholesale market	Mature whole sale market
Maintenance	Check equipment manually	Monitor equipment remotely
Reliability	Estimated	Predictive

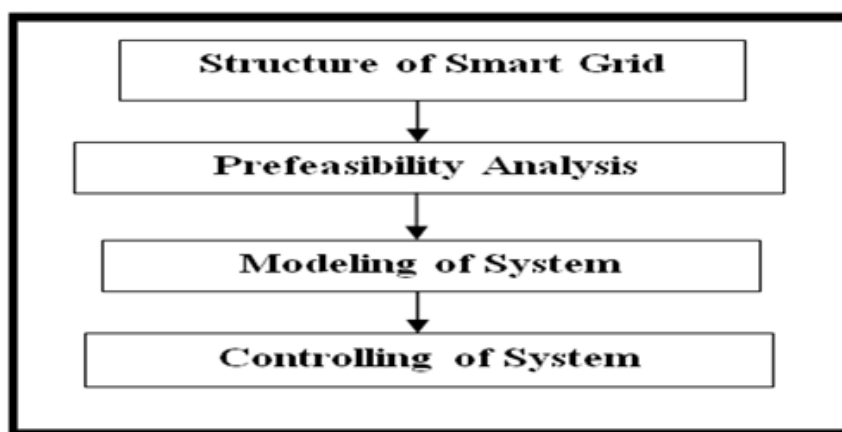


Figure 3 Structure of smart grid.

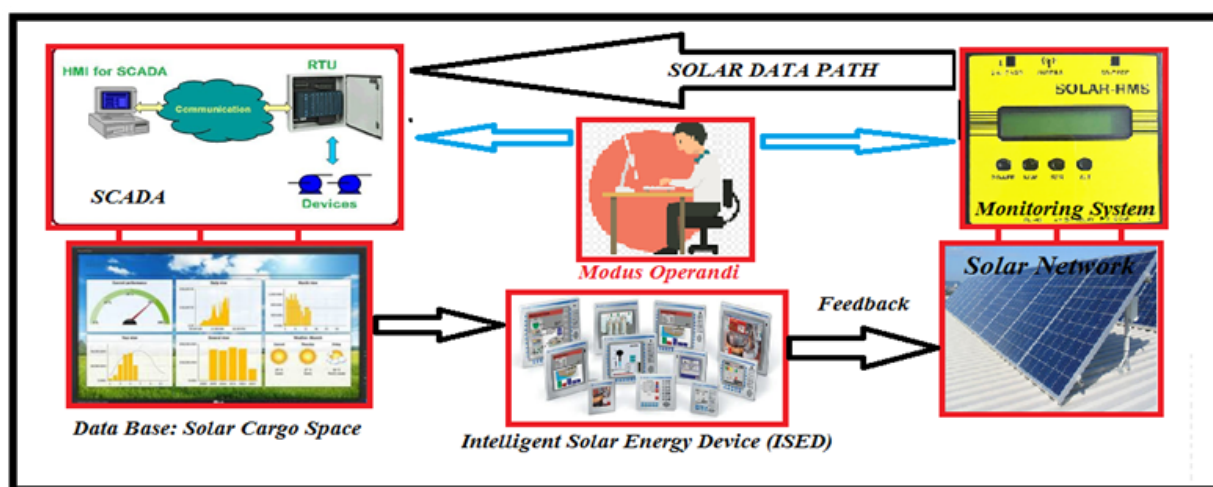


Figure 4 Smart grid based solar energy system.

Table 4 Architectural design based summary of smart grid

Author	Architecture	Technique	Outcomes
Ali ³⁰	Wide area smart grid	SCADA	Analyze function of smart sensor, smart meters, phase measuring unit
Nazmus ³¹	Smart grid	Real time technique	Identify challenges with the cross function of power & communication
Divya ³²	Secure architecture smart grid	Hybrid encryption algorithm & digital signature	The strength of the model has been verified with the help of attacker
Pavan ³³	Smart micro grid	Information & communication technology	Paper presents overview of distribution system automations
Lopes ³⁴	Model based smart grid	System modeling language	Smart grid as a self sustaining energy enterprises
Ringler ³⁵	Smart electricity grid	Agent based modeling	The approach can deliver valuable input for decision process of stockholder
Reks ³⁶	Demand side response smart grid	Stochastic optimization & reduce task network	This scheme proposed is validate with practical results which shift the demand from peak to non-peak periods.

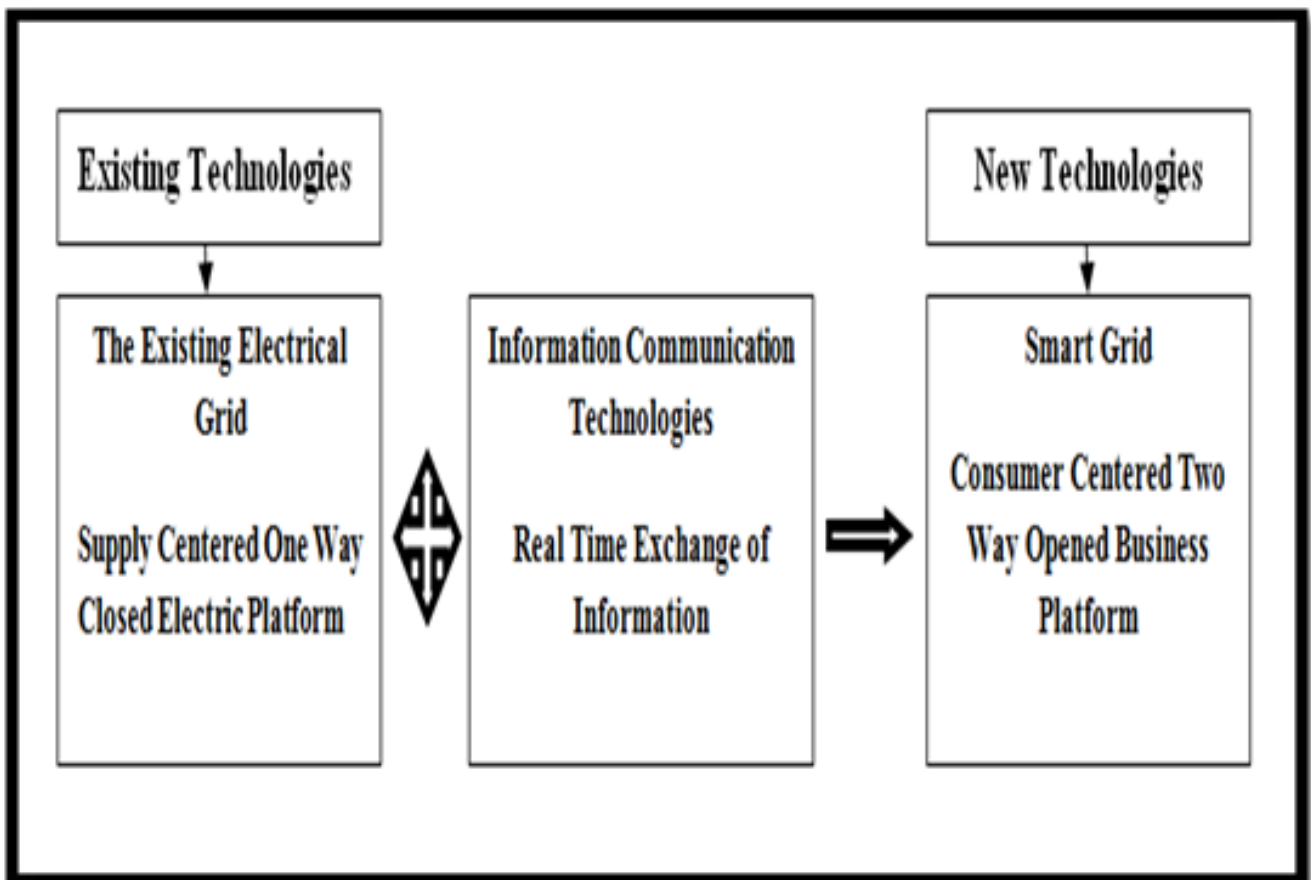


Figure 5 Path of new technologies based smart grid.

The capacity of the framework is assessing and creating viable and productive brilliant network advances, surveying the advantage of the keen matrix extends and choosing more viable and more proficient ventures. In³³ illuminated key parts of basic diagram of savvy lattice for computerization, transmission and course system. The noteworthy test lies in appointment structure robotization is the assurance of honest to goodness designing and exchanges parameter and find ached for yield. In context of each one of these perspectives and given parameter, this paper shows a layout of course structure robotization as a bit of insightful framework exercises and its basic segments viz., plan arrangement and commitments. Building design of keen lattice and give the procedures that are incorporated to get a handle on a helpful brilliant matrix as a self doable essentialness wander and show the troubles and favorable circumstances of finishing capable shrewd system.³⁴ Further³⁵ cleared up pro based showing and reenactment of sharp system and the dread of the keen structures and markets mission and vision constitutes a huge transmission and transport of energy systems affecting a couple of accomplices and made distinctive specific, social, monetary, and common and natural challenges. Demand response showing and plan strategy for private clients and system is penniless down using redirection theory estimation and what's more by Dominant Game based Energy Scheduler.³⁶ A various data distinctive yield orthogonal repeat division multiplexing (OFDM) structure for sharp grid evaluation, which is proposed for narrowband control line correspondence (NB-PLC) applications for medium-voltage (MV) frameworks.³⁷ Exhibiting and propagation of feasible power sources in splendid structure using (DEVS) formalism.³⁸ The approach models four major parts in splendid network which are: adjacent planetary gathering, wind structure, accumulating contraptions and the given load ask. The basic walk in arranging a sagacious power and essentialness structure is to exhibit and recreate the various fragments of insightful grid remembering the true objective to settle on correct layout decisions and establishment. In this paper, a showing and entertainment approach in DEVS condition is proposed. Elucidated exhibiting and proliferation of savvy network and an administrator based showing and amusement approach is sensible for exhibiting repeat control in the sharp system. Other than the reenactments raise that demand response could be an achievable option for whatever time span that basic control abilities to the splendid cross section despite

when stood up to with correspondence constraints.³⁹ Further⁴⁰ made exhibiting and building structure and substantiation of insightful grid for wind control blend. The model combines generator and load controllers which empowering suppliers and demanders to offer in a Real-Time Pricing (RTP) control exhibit. The arrangement structure is associated with address a physical exposure broaden drove on the Olympic Peninsula, Washington, USA. Table presents rundown of engineering plan of brilliant framework (Table 4 & Figure 5).

Reliability in solar system & smart grid

Reliability is characterized as the possibility of a gadget or framework playing out its motivation sufficiently for the proposed working timeframe. It is likewise as capacity of electrical power structure to supply the framework load with sensible consistency and nature of supply.⁴¹ keeping up supply firm quality of little, detached power frameworks utilizing sustainable power source. In this paper deterministic and probabilistic strategy is joined utilizing a framework will being way to deal with give valuable unwavering quality lists to little, segregated power frameworks (SIPS) containing sunlight based breeze half and half framework. An assessment of the commitment from PV and WES to SIPS unwavering quality is exhibited and⁴² built up an outline of an ideal HRES thinking about dependability files. In this paper subjected to money related and logical requirements. The specialized imperatives identified with framework unwavering quality are verbalized by the proportional misfortune factor. The unwavering quality record is ascertained from part stoppage that incorporates WT, PV cluster, battery, and Inverter disappointment. Advance⁴³ exhibit effects of sustainable power source entrance on nodal cost and nodal firm quality in deregulated control framework. In this paper the firm quality of wind and sunlight based power are examined in a poolco advertise activity. The technique catches the ordered implementation of list firm quality examination has been proposed. An firm quality evaluation of PV-Wind cross breed framework utilizing Monte-Carlo reproduction. This paper will talk about the different parts of HES including PV and WECS and their displaying for dependability examines. A few strategies for unwavering quality assessment have been accounted for in this paper.^{44,45} Presents enhancements of framework dependability are mapped with the support of energy gadgets (Figure 6) (Figure 7).

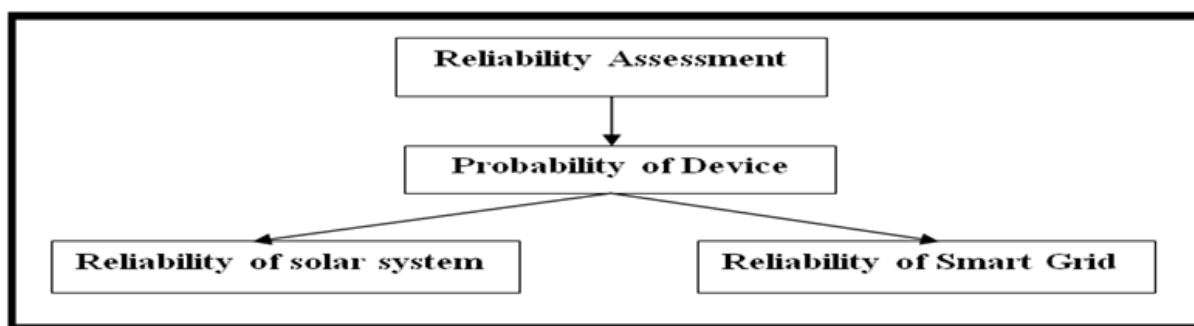


Figure 6 Reliability assessment.

A probabilistic dependability assessment of off matrix little half breed sunlight based breeze control framework for the country charge in Nepal. This paper is centered around the examination and investigation of cross breed framework unwavering quality in view of different dependability records like Loss of load desire (LOLE), Expected vitality not served (EENS), Energy list of dependability

(EIR), Expected client interference cost (ECOST) are assessed through probabilistic approach utilizing explanatory strategy.⁴⁶ In paper⁴⁷ the impact of adding solar energy sources and energy storage to a microgrid distribution system is investigated. Markov modeling is used to model the energy storage as well as to assess the overall reliability of the system Markov modeling is used. Roy Billinton Test

System (RBTS) is used to approximation different loads and system indices, including System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI), Customer Average Interruption Duration Index (CADI), Average System Unavailability Index (ASUI) and Energy Not Supplied (ENS). For distribution expansion planning⁴⁸ paper presents a framework to

assess the investments in Battery Energy Storage Systems (BESS), considering a high penetration of solar photovoltaic (PV) distributed generators.. In paper⁴⁹ a stochastic analysis method is studied and applied to the assessment of PV integrations on the 11.4kV distribution feeder that serves as offshore wind turbine (WT) testing site in Taiwan and analysed by MATLAB and Open DSS co-simulation technique.

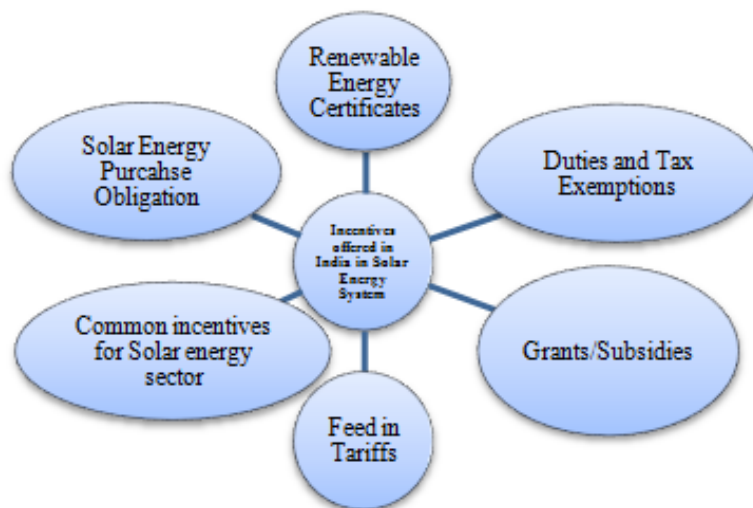


Figure 7 Incentives offered in India in solar energy system.

Conclusion

Smart Grid is an unavoidable pattern of energy framework, and shrewd matrix thorough evaluation framework can direct a complete appraisal of the general attributes of savvy lattice, which can mirror the present level of the improvement, discover the shortcoming and the limitations in the system advancement, distinguish the separation to the objective, guarantee the brilliant network improvement accomplish a unification of the quality, speed and effectiveness. At present, numerous nations are examining on the savvy lattice far reaching appraisal frameworks. Number of authors address different architectural design related to configuration of smart grid. The key challenge lies in transmission & distribution system automation is the assortment of proper structural design and communications parameter and find out desired output. It is necessary to develop architectural design of smart grid on the based on energy conservation & energy efficient manner as well as minimum carbon emission concept, which is very beneficial for sustainable development. The proposed smart grid appraisal framework should regard keen network as a natural entire, mirror the data, computerization, interoperate highlights, give full thought to the electric vehicles, vitality stockpiling, other esteem included administrations model and social advantages of vitality sparing and condition assurance, shape a solidarity shrewd lattice assessment framework based on mirroring the time contrasts and provincial contrasts aimed the brilliant network improvement.

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Conflicts of interest

The author declares there is no conflicts of interest.

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