Challenges of Smart Integration Systems: A Review

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***Abstract*—Recently the important for Distribution Generation (DG) take large scale for researchers. But future electricity demand will grow. This requires attention by implementation smart integration now. This aim to the intelligent integration where grid-connected PV systems, wind energy systems that are planned for a dynamic interface with the grid in the context of so called smart integration between the distribution generation resources and the power generation system. The development in smart integration will solve more problems for network such as: (1) improve the efficiency in production, (2) consumption of electricity, and (3) increase reliability of integration of renewable energy into the grid. This requires control strategies, metering and monitor technology. It's aim to automation processes. The renewable Distribution Generation (DG) such as solar photovoltaic (PV) and wind has received a great attention. This paper aimed to wide survey of researchers in the field of the micro-grid until this moment down to the smart integration.**

***Index Terms*—renewable energy, PV systems, micro-grids, storage systems, integration of PV with grid**

I. Introduction

Now a day's global energy demand will be increase. The increasing energy demands are the major challenge for technology development, economic growth and stability for the best utilizing of the renewable energy. Where the traditional generations or central generation by the fossil fuels cause more pollution, co2 increase and temperature increase by mean unfriendly environmental. But renewable energy is considered friendly environmental. Governments put in new legislations and nutrition in tariffs to encourage the investors to install new renewable energy utilization sites and studies on this subject by many institutions [1]-[3]. The renewable energy systems are suitable for maintaining the energy sustainability. Wind energy and photovoltaic panels (PV) is the major implement for the renewable energy and used to test. The wind energy and the solar sources not enough for sustainability and power quality alone but need to the smart system (intelligent energy management system) for sustainability on the load side presented in [4].

The concepts of sustainability, it includes maintaining a suitable quality of life while providing of the long-term protection of the environmental in an economically feasible manner [5], also presented renewable energy for high performance building in New Jersey by implement of PV, Wind power.

The Renewable Energy Sources (RES) is better option for constructions of modern electrical grid. The world is making a lot of effort to change the reliance on centralized generation (requires fossil fuels cause pollution environmental) to rely on Distributed Generation (DGs) in the future by large margin which includes the economic benefits, environmental and social.

All technologies continue to be supported, recognizing that each has its own merits and benefits to society and the environment. Some of these technologies are development of renewable energy in micro-grids. This considered the key points for solving problems in utility grid due to blackout or increasing load and also treatment the losses in the electric network. The viewpoint found in [6] Although the ideal power requirements vary by a consumer, and the main components of the power system ideal - such as smart technology, redundancy, distributed generation and storage, cogeneration or combined heat and power, and consumer control - work together with the large scale of power grid or system quantities as an integrated whole to provide consumers with maximum economic and environmental benefits, reliability and efficiency.

This paper will survey: (1) Renewable Energy which addressing for Solar Photovoltaic and Wind Energy systems. (2) Concept of micro-grid and its benefits. (3) Storage Systems to improve the performance of integration micro-grid with electric network. (4) Survey of smart grid.

II. Renewable Energy

A. What Is the Renewable Energy?

Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, wind, rains, and tides of ocean, biomass and geothermal resources form heat generated deep within the earth [7]. Several of renewable resources harnessed for electric power generation. The renewable energy technologies are more sustainable than

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the many current sources of energy. Sustainability analysis's, which has dependency on three main components: economic and financing, externalities costs, environmental effects. Each one of these variables has a major impact on the application of the renewable energy [8].

In general renewable energies depended into two main factors: first distribution of the natural resources and geographical location and the second factor is growth rate and infrastructure.

The use of renewable energy is expected to increase significantly in the European Union to reach the 20% of the final energy consumption and 10% of renewable energy in transport by 2020. It is expected contribution of renewable energy by 55%-75% of the total final energy consumption by 2050. In paper [9], the researcher presented that an analysis of the biomass needed to reach the 2020 requirements. With the relationship between domestic supplies is expected potential biomass. These analysis by mentions the EU policy framework for renewable energy, sustainability requirements for bioenergy also renewable energy and bioenergy projection for 2020 with expected development of RES and bioenergy contribution. It significant expected domestic biomass supply and the future biomass demand and potential.

The significant contribution of [10] is the knowledge on the Perceived Ease of Use (PEOU), Perceived Usefulness (PU) and impact cost of the renewable energy technology in Malaysia. It is considered an important factor in influencing the intention to use the renewable energy. The renewable energy policy depend on the motivate policy makers to pay more attention to the role of public perception.

In paper [11], the authors presented a comprehensive review of optimal sizing, energy management, operating and control strategies also integration of different renewable energy resources. Which it mentioned the different controller for integrate such as hysteresis controller, proportion control, micro controller and fuzzy controller. Authors focused on design and implementation of grid-connected and stand-alone hybrid energy system. The advantages and disadvantages of the configuration for the hybrid systems were studied.

An analysis of the optimal portfolio up to 2050 was conducted for representation of renewable energy technologies and the cost effect using bottom-up model for electricity generation sector in South Korea. Methodology analyzed by energy system model and time model. It uses two scenarios: the first is PV and wind power strengthening and the second scenario represent the other renewable energy strengthening to indicate that the renewable energy will be able to play important role in decreasing the GHG emission if R&D have successfully reduce investment and operating cost of PV and wind power. Also the additional cost of increasing the target value of the renewable energy is 20% of the competitive technologies [12].

In [13], the authors present the optimal probabilistic energy management by decrease of operation cost related to PV output power, wind turbine output power and load demand based-on Robust Optimization (RO) and Point Estimate Method (PEM). An optimal strategy for operating a micro-grid with capability of operating in islanding mode is proposed. The MG includes two residential feeders and one commercial feeder as shown in Fig. 1. The authors noticeable a short-term energy management scheme in a typical MG including renewable and conventional DGs. the optimal energy management of the MG and uncertainty modeling are formulated as follow:

a) Technical constraints of the micro-grid should be operating.
b) MG operation cost modeling.
c) Uncertainty modeling (probability of difference between the forecasted value and the real value).

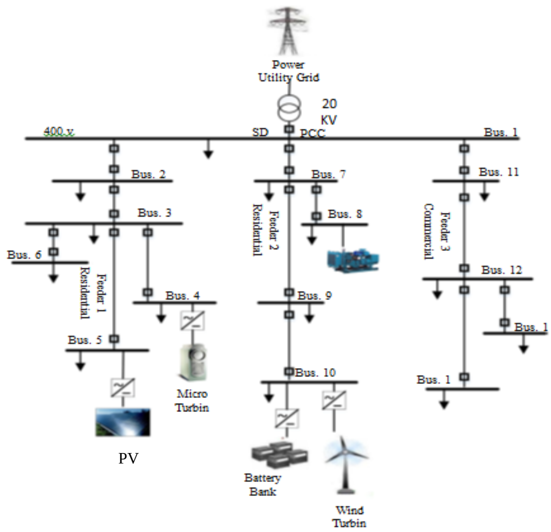

Figure 1. The proposed of micro-grid topology.

The problem will be analyzed with different scenarios and recommended as the most robust solution. The methodology based on Particle Swarm Optimization (PSO) algorithm was proposed. The result noticeable that applying DGs as well as battery unit in a MG system will decrease total operational cost and the MG reliability increased.

The significant contribution of paper [14] is a survey for result and methodologies the flexibility requirement of renewable energy based on the electricity system. The methodological analysis studied by many research that different approach are available to assessment the technical potential, economic potential and marked potential based on flexibility option. The result for the flexibility requirement studied from the German and European energy system. And discuss a conceptual framework to quantity the market potential of flexible technologies.

The optimization of electricity generation of tidal power plant with reservoir was studied by [15]. This paper presented the proposed a strategy of sequential dispatching of turbines during the generation process to maximize the energy generated by tidal power plant in each cycle, even with restrictions in the reservoir. The results were concluded that a significant exploitation of Bacanga estuary is still even with the physical constraints that prevent the full exploitation of its potential.

In [16], the key of technology for energy efficiency and renewable based on power electronic was discussed. It presented the contribution of power electronic for renewable energy (wind, solar), as an important future contributor.

At the end the advantages of using renewable energy can be summarized as follows [8], [11], [14], [17]:

1) Renewable energy is more environmentally friendly. Even though renewable energy might also cause some environmental problems such as the pollution involved in manufacturing solar cells, renewable energy is generally much cleaner than traditional fossil fuel.
2) Renewable energy, like wind energy and solar energy, can provide nearly infinite energy if used properly. This is quite different from the traditional energy resources such as fossil fuels. Non-renewable energy resources normally require a long time to generate. Once the non-renewable energy is used up, its regeneration is impossible in the near future.
3) Renewable energy resources are usually decentralized, and as such the use of renewable energy is more flexible. Instead of depending on national network management, renewable energy can work in small scale and becomes self-supportive in the local community. For instance, people can harvest solar energy over the rooftop as a supplement energy source. If the power network provides a way to integrate such distributed energy sources, people can trade extra energy over the network. Such flexibility will fundamentally change the energy market in that end customers can be both energy consumers and energy contributors.

B. Challenges in Renewable Energy Development and Management

There are three major technological changes are involved in the development of renewable energy [18]: (1) Energy saving on the demand side [19], (2) Efficiency of renewable energy production [20], [21], and (3) Replacement of fossil fuels by various sources of renewable energy [22], [23]. To some degree, these technologies are the necessary components for success in developing renewable energy.

Uncertainty about the amount of renewable energy available, along with distributed power generation, leading to challenges in the management of renewable energy resources. For example, the amount of energy available is uncertain in the future requires new technologies such as large energy storage devices to reduce the gap between energy demand and energy supply. Add to this, energy sources and distributed geographically, and building power distribution network is more difficult

One of the challenges is to integrate also a large share of distributed generation in the energy system, especially the supply of electricity [24]. Recently, good progress to address this problem was presented. For example, a number of studies for the integration between wind power and solar energy with the network carried out and new technologies such as fuel cells and hydrogen that have been applied in distributed power generation [25]-[28]. These studies illustrate the possibility of successfully distributed resources integrated with the energy system; also it shows that the ability to integrate renewable energy is determined by the flexibility of the rest of the supply system [29]. The development of new energy distribution networks has become a critical issue one.

III. PV Systems

The earth receives 174 pita watts of incoming solar radiation at the upper atmosphere. About 30% is reflected back to space. But the rest is absorbed by clouds, oceans, and land masses. As shown in Fig. 2.

Today, global energy demand will be near to tow times and it will be increase by the end of this century. For cover this point the major challenges such as achieving technologies advancements, political stability and economical. The advancement technology needs growing research and developments in the area of solar cell technology. There are three types of photovoltaic modules on the market were discussed in [30], crystal silicon type is the first generation and widely use in solar cell applications. The second generation technology is thin film of amorphous silicon type and considers low cost electricity as compared with the first. The concentrated, organic and dye sensitize solar cell type is third generation solar cell and it is not widely commercialized. The author aspects in future that the use of nanotechnology is the ladder to development of newer solar cell with much power cell energy at cheaper cost.

There are many advantages of solar energy for example: the inexhaustibility of solar energy, it considers zero environmental pollution, it is without geographical restrictions, and it comes with the great convenience of installing it anywhere. PV cells can be used as independent energy systems Micro-grid and also can be connected to the main power grid. The disadvantages of solar energy are energy losses. Where the energy lost is in the converter switch as well as the energy losses in the output filter.

Photovoltaic technology is the most widely technology in the renewable energy market. It describe the generation of electricity from natural solar light. A photovoltaic cell was first installed on a satellite in march1958 (on the vanguard 1 satellite) [31].

A. History of Solar Cells [32]

- The world production of photovoltaic cells exceeded 500W in year 1977.
- The world production of photovoltaic cells exceeded 21.3KW in year 1983.
- Total photovoltaic power installed in the worldwide reaches 1,000megawatts in year 1999.

- The installation cost of photovoltaic modules reach nearly 6000$/KW in year 2008.
- The global solar cell production reached 9,340 MW in year 2009.

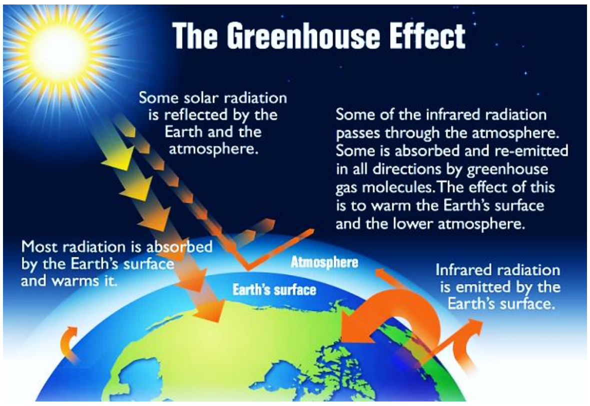

Figure 2. Earth greenhouse effect.

In [33], the author discussed the benefits of the solar energy for the power generation in Cyprus. It proposed to Electricity Authority of Cyprus to recommend the government of Cyprus to establishment of photovoltaic plant of 4.3MW, to cover the parking area of Larnaca international airport. Also proposed construction and operate of a 50MW concentrated solar power plant by using 640 parabolic trough collectors. Both technologies have their advantages but the PV have lower cost than the concentrated solar power.

In paper [34], the authors presented the design and operation of standalone residential PV system in Egypt. PV system is used to feed load of 2kW for household during day and night hours by integrate PV array. Push-pull inverter and filter with storage batteries and their controller. By using LC filter the total harmonic distortions THD decrease, which match the IEEE standard limit for harmonic distortions in low voltage (voltage less than 2.3kV). Where the output voltage waveforms tested and found it sinusoidal in waveform and recorded for different load demand values.

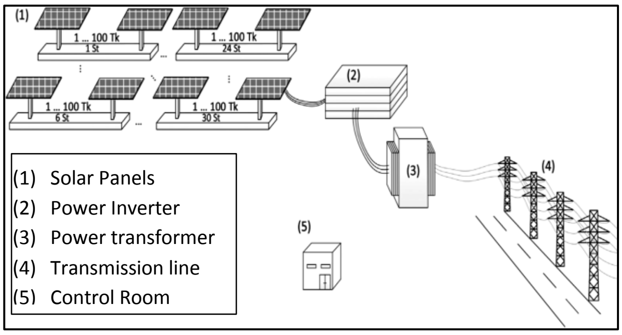

Figure 3. Photovoltaic solar plant connected to the grid.

The significant contribution of this paper [35] is studying parameters which effect of improve the performance of a photovoltaic solar plant in Chile. A 30MW photovoltaic solar plant was proposed and design to connect with a 220kV electric grid, the plant contains 30 module of 4400PV panels with 235W nominal power. The generated energy from the plant go to the grid through 1MW inverters connected with the power transformer 32/220kV. Arrangements of the photovoltaic solar plant are shown in Fig. 3. Net Present Value (NPV) and Internal Rate of Return (IRR) were used as a limit of the performance of the plant. The sensitivity analysis used to understand the effect of these parameters on the financial performance of the PV plant and obtain the benefits of this project.

Paper [36] referring to that author has proposed a literature review of maximum power point tracking for PV system. MPPT used generally for the selection of the maximum power from the PV module and turning that power to the load where The converter acts an interface between the PV module and the load as shown in Fig. 4. There are several types for MPPT as shown in Table I [36].

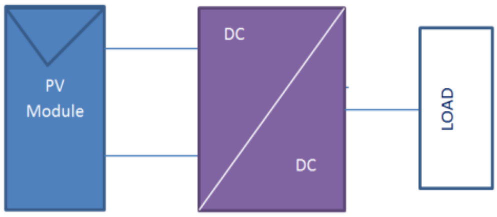

Figure 4. Block diagram of typical MPPT system.

The application of MPPT used when the source of the power is nonlinear such as PV modules. In general the MPPT system used for PV systems such as: connection with the grid, standalone system and battery charge. As shown in Fig. 5 and Fig. 6.

TABLE I. CLEAR VARIOUS ALGORITHMS FOR AUTOMATIC TRACKING

No.	Methods	No.	Methods
1	Perturb and Observe	8	Neural Network
2	Incremental Conductance	9	Current Sweep
3	Parasitic Capacitance	10	$^{dP}/_{dV}$ or $^{dP}/_{dI}$ feedback control
4	Voltage Based Peak Power Tracking	11	Fractional Open-Circuit Voltage
5	Current Based Peak Power Tracking	12	Fractional Short-Circuit Current
6	Fuzzy Logic Control	13	Other MPPT Technique
7	Ripple Correlation Control		

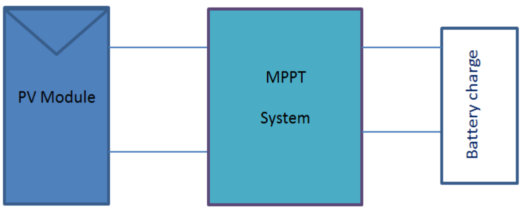

Figure 5. Application of MPPT for battery charging.

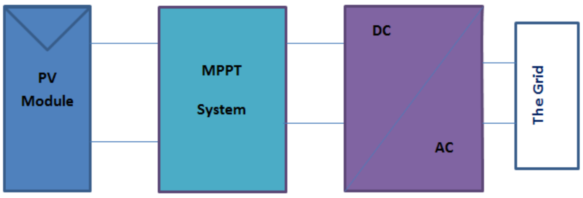

Figure 6. Application of MPPT for grid connection.

Dissection of electricity power consumption under a photovoltaic micro-grid system in India was discussed by [37], the author identify the major factor that determine power consumption level for the one of PV micro-grid project in India. First detail of the power plant is 120 kW PV power plant was installed and starts operation in 2006 and feeding 196 household in 2009. The electricity demand in the village based on household connection and the trend of electricity consumption was mentioned. The stability of power supply reviewed. A regression model used, existing in (SPSS) program which it depend the explanatory variable like (No. of point connect household, Temp.) that the best explain the daily electricity consumption. It found the average per-household consumption of electricity almost stable. The authors investigate in the future studies the relationship between capacity of battery bank and the degree of absorption of fluctuation due to weather conditions.

The concepts of this paper [38], for reduce the cost of the grid connected with PV system. Variable ways interested for instant: PV modules connected together to produce amount of electricity based on value of voltage and current. A number of PV modules connected in series making PV generators (PG). It connected with grid based on electronic inverter where the benefits of inverter make monitor for grid connection and isolate PV array if grid problem occur.

The significant contribution of this paper [39] is design and implement of 100KW rooftop grid connected a PV system. The author used an institutional building at Minia University, Egypt as case study. The system methodology studied based on monthly best tilt angle, calculation of radiation on the tilted surface and make calculation of average power for A PV module. Where the equivalent electrical circuit describing the solar cells array was used for analysis is shown in Fig. 7. A line-tied inverter was used with the utility connected PV system. The Cost of Electricity (COE) and economical of the system were studied. It found the 100KW rooftop grid connected PV system avoid 145.97 ton CO_2 emission due to thermal energy needed of same electricity from the existing utility grid.

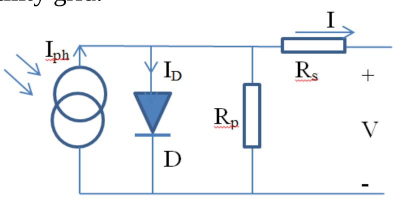

Figure 7. Equivalent circuit of PV.

B. Description and Forms of Photovoltaic Cells [40]-[42]

Fig. 8, Fig. 9, and Fig. 10 clear the different forms of PV cells.

Figure 8. Single photovoltaic cell.

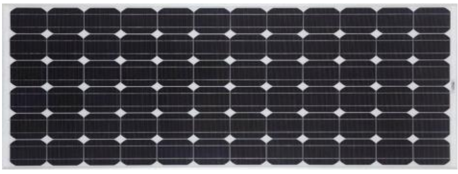

Figure 9. PV module.

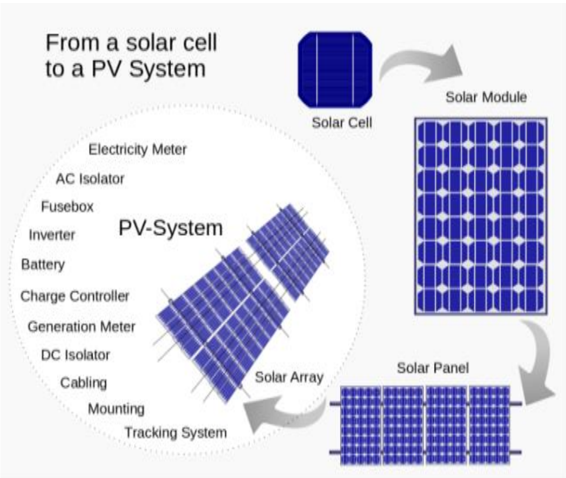

Figure 10. Development of solar cell arrived to PV system.

A dynamic electrical scheme for the optimal reconfiguration of PV module was presented in [43] under non homogeneous solar irradiation. The optimal reconfigurations algorithm depending at the four steps are the following:

a) Initialization;
b) Data acquisition;
c) Search of the best configuration;
d) Reallocation of modules;

It proposed the DES to increase production power of PV system under partial shading of modules compare to the power generator of the static configuration.

C. Simulation of PV

A simulation for the operation control of PV system connected with grid was presented in [44], it stablished the simulation platform of Grid-connected PV system as shown in Fig. 11. It designed by applying double closed-loop control of voltage and current by warranty stable DC output. This simulation considers guideline for practice design.

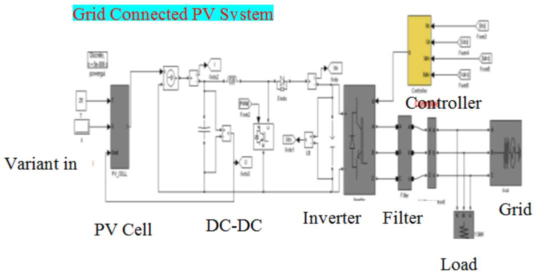

Figure 11. Simulation platform.

A simulation of small scale PV system using HOMER Softwear was presented in [45], it use HOMER to simulate the dual-tariff concept system design for solar PV plants based on a real structure in Dhahran, Saudi Arabia. A standalone system of PV module located on the roof of building or on house need aload of ≥10KWH/day was insulated. A dual metering tow ways - net – metering is used as shown in Fig. 12. This new metering system is available in many countries all over the world, where the net-metering technology becomes one of the typical emerging technologies to increase the consumer contributions to the grid.

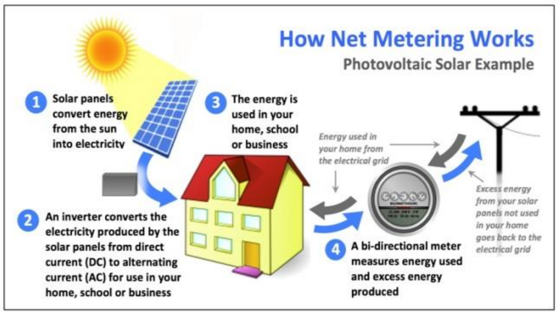

Figure 12. Tow way – net – metering.

A stand-alone hybrid PV/Fuel Cell power system for the city of Brest in France presented in [46], as the optimal design. It uses the HOMMER – based optimization study was focused on economic performance and the loss of the power supply probability concept.

A modeling and simulation of PV system interconnected with the electrical utility was presented in [47], it use EL'Zafarana power plant in Egypt as a case study by using computer program applied on modeling and simulation of specified PV system interconnected with the electrical utility. The total harmonic distortion reached 3.4% for the inverter current from PV. Also for the same case study the significant contribution of [48], [49] for optimal States operation of PV with utility grid interconnected power system using neural network. And proposed operation strategy to decrease the price of kWh produced from photovoltaic system by full utilization of PV energy through the year using battery storage system.

IV. Micro-Grid

A. Definition of Micro-Grid

Micro-grid in United Department of Energy (UOE) is defined as:

A group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid. A micro-grid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode [50].

Also define in [51] as: a micro grid operates in both grid-connected and in isolated modes. In each mode of operation there could be different combinations of the available energy sources in the systems that are catering to the load demand.

In [52], the author making a similar effort to define the Micro-grid as “ a low voltage, distribution network which is miniaturized version of a self-sustaining energy model which able to generate, distribute and control bidirectional power flow within its boundary of operation in a coordinated, controlled, intelligent & efficient way, with focus on integration of green energy sources.

B. Benefits of Micro-Grid

The benefits of micro-grid can be found in [52]-[56].

a) Management the load demand on the grid network by direct load control to pricing incentive for customers.
b) It prevents the need for transmission line extension in some cases.
c) Reduces the losses in transmission and distribution by approximately 3% compared to T & D by the centralized generation.
d) Operating in autonomous mode to preventing cascading blackout.
e) Suitable for connecting mix generation like DGs.
f) Two-way power transfer (import/export power to the grid).
g) Integrating renewable energy resources like Solar, Wind, and biomass etc., green power generation.
h) Remote area consumer gain down to electricity.

C. Micro-Grid Architecture

In Fig. 13 shows the micro-grid structure [57] where the interface connection between the micro-grid and the main grid called point of common (PCC) is on the primary side of the transformer. The micro sources are PV or fuel cell interfaced to the system through power electronic. The critical load (sensitive load) connected on feeder A, B, C and the traditional load (non-sensitive load) on feeder D. the micro-grid can operate in two modes:

a) Grid connected mode, the micro-grid can work in two directions (import/export) with the main grid.
b) Islanded mode, for any disturbance of the main grid the micro-grid isolated itself by switching and operates in Islanded mode to feeding power to the critical load.

An efficient capacitor based on Genetic Algorithm (GA) with new coding and operators' allocation in micro-grid with grid-connected mode and islanded mode of operations at different load level was discussed in [58], the author used 9-Bus distribution test system and 24-Bus for study. If the micro-grid operated in islanded mode necessarily need to reactive power sources and voltage deviation from the nominal value can decrease effectively with a DG operating in the PV mode.

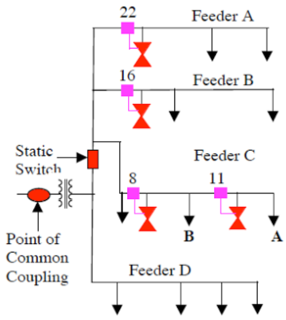

Figure 13. Micro-grid structure.

In this paper [59], present a PV micro-grid based on analysis of electricity consumption in India. It study actual households connected to micro-grid, electricity use, factors affected their consumption level, and change of consumption level over time, by implementation of PV micro-grid rural electrification projects. The result simulated and compared with the actual daily electricity consumption data. These methods provide useful clues for optimization of expansion process of decentralized renewable energy systems with micro-grids.

Due to fluctuating and nonlinear load in the main grid, a multi-objective control strategy used to improve the efficiency of the power electric systems by integration of micro-grid based on renewable distributed generator (RDG) to the electrical network was discussed in [60] to eliminate the harmonic distortion.

V. Storage Systems

For unbalanced solar irradiation conditions the Energy Storage System (ESS) used in grid connected PV plants to improve the whole power generated. By experimentally measurements in [61], energy storage, operated by means of batteries installed in grid-connected photovoltaic system with distributed as show in Fig. 14. Due to the presence energy storage system possible to integrate with other different renewable energy, more great availability in AC power grid, reduction of peaks of load power demand, avoid uninterruptable power supply.

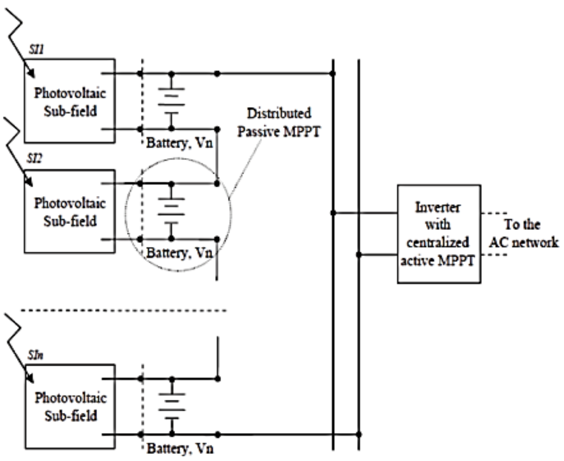

Figure 14. Grid-Connected PV system with distributed use of batteries.

Storage systems plays important role in grid integration. It can store the extra energy where can provide the energy during drop in voltage or power blackout.

In [62] Energy storage can be used to store for short-term the peaks in electric power during periods of unloading network, and also to cover the drops in power during normal operation, for example when clouds pass over the plant of PV system or for any change in weather conditions. Also Energy storage can be used to improve power quality parameters and to back up the energy for the first category of consumption. Energy storage devices are necessary for operation of Smart-Grids as well as for the local networks Micro-Grids

A. *Types of Energy Storage*

a) Battery Energy Storage (BES) [63], it is suitable storage technology for PV system.
b) Regenerative Energy Storage (RES) [64].
c) Flywheel Energy Storage (FES) [65].
d) Supercapacitor Energy Storage (SCES) [66].
e) Superconducting Magnetic Energy Storage (SMES) [66].

Energy storage plays an important role with the integration of electrical power systems, and is one of the solutions in the continuity of energy and increase efficiency. Energy storage is the enabling technology to achieve the decoupling of generation and demand required to increase the share of renewable energies in the generation mix. Energy Storage Technologies such as: Mechanical Systems, Electromagnetic Systems, Electrochemical Systems, and Thermal Systems were discussed in [67]. Fig. 15 shown the existing solutions are classified according to their operating principle.

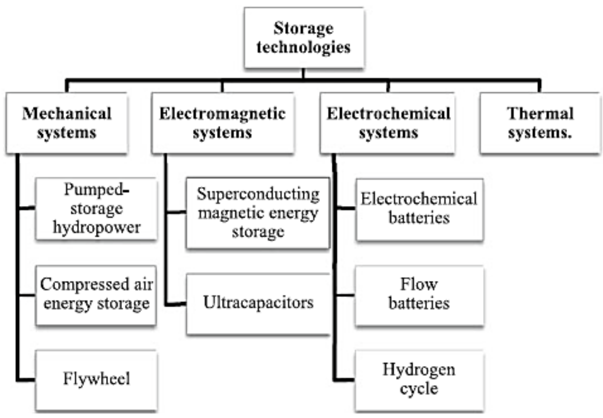

Figure 15. Energy storage technologies.

B. *Possibilities of the Storage Energy*

Storage devices assets enhance the operation of distributed energy resource in distribution grids in three ways was presented in [68].

a) They can enable a constant and stable output (stabilization).
b) They can bridge the lack of primary energy such as sun and wind.
c) They enable also fluctuating generation types to operate as dispatch able units.

The significant contribution of this paper [69], the results that requirements on storage devices assets located in distribution grids to reduce the feed-in peak of distributed energy resource generation. Also reduce the reinforcement need in grids and the need for traditional power plants as backup capacities and important for a sustainable electricity future. It considers forms a basis for future research on the choice of appropriate technologies of storage assets.

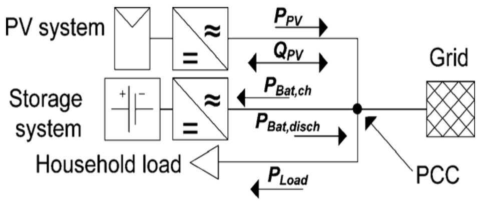

Figure 16. Grid connection of PV storage system, [70].

C. Voltage Control Strategies Using PV Storage Systems

PV storage systems which are capable of voltage control can improve PV grid integration as shown in Fig. 16. Different voltage control strategies for PV and PV storage systems were introduced in [70], Dynamic voltage dependent control strategies for PV storage systems offer a high potential to handle the trade-off between curtailing energy and violating voltage limits.

Table II, summarizes the investigated strategies for PV storage systems based on static and dynamic control using not only the PV inverter, but also the battery.

VI. INTEGRATION PV WITH GRID

In case of PV generation the distributed energy resource is partially weather-dependent and non-schedule. This mean the advanced control of the power system required to maintain the reliability of the system. Integration keys need to be addressed from the distributed generation DG side and from the grid side. Advanced inverter, controller, and interconnection technology development must produce hardware that allows PV to operate safely with the grid and act as a grid resource that provides benefits to both the grid and the owner.

TABLE II. ANALYZED VOLTAGE CONTROL STRATEGIES FOR PV STORAGE SYSTEMS

No.	Strategy	Equations for strategy as in [70]	Description
$PVBat\ 1$	$stand.Operation$	$P_{res} = P_{pv} - \lvert P_{load}\rvert$, P_{res} $is\ residual\ load$, $P_{Bat,ch} = -P_{res}\ if\ SOC < 1\ and\ P_{res} > 0$ $P_{Bat,desch} = \lvert P_{res}\rvert\ if\ SOC > 0\ and\ P_{res} < 0$	- No voltage control
$PVBat\ 2$	$60\% - P + PF(P)$	$P_{pv} = \begin{cases} P_{pv\,max} & if\,P_{pv} \leq 0.6.P_{STC} + \lvert P_{load}\rvert \\ 0.6.P_{STC} + \lvert P_{load}\rvert & if\ P_{pv} > (0.6P_{pv} + \lvert P_{load}\rvert\ and\ SOC = 1 \end{cases}$	- Fixed P_{pv} curtailment with Q_{pv} Provision
$PVBat\ 3$	$P_{Bat} - Q_{pv} - P_{pv}$	$P_{Bat,ch} = \begin{cases} -P_{res} & if\ SOC < 1\ and\ V_{pcc} < V_{thres}\ and\ P_{res} > 0 \\ -P_{pv} & if\ SOC < 1\ and\ V_{pcc} > V_{thres}\ and\ P_{res} > 0 \\ 0 & if\ SOC = 1\ or\ P_{res} < 0. \end{cases}$ If battery charging is not enough to lower V_{pcc} again, the PV system follows the AVL strategy *(PV3)* $P_{pv} = \begin{cases} P_{pv\,max} & if\ V_{pcc} < V_{thres} \\ P_{pv\,\max} & if\ SOC < 1\ and\ V_{pcc} > V_{thres}\ and\ \lvert Q_{pv}\rvert < Q_{pv\,max} \\ P_{pv\,red} & if\ SOC = 1\ and\ V_{pcc} > V_{thres}\ and\ \lvert Q_{pv}\rvert = Q_{pv\,max} \end{cases}$ And Q_{pv} as follow, $Q_{PV} = \begin{cases} o & if\ V_{PCC} < V_{thres} \\ o & if\ SOC < 1\ and V_{PCC} > V_{thres} \\ -Q_{PV} & if\ SOC = 1\ and V_{PCC} > V_{thres} \end{cases}$ Also, $P_{Bat,disch} = \begin{cases} /P_{res}/ & if\ SOC > 0\ \ and\ V_{PCC} < V_{thres}\ and\ P_{res} < 0 \\ 0 & if V_{PCC} > V_{thres}\ or\ P_{res} > 0 \end{cases}$	- Voltage dependent charging of the battery with priority on P_{pv} – charging
$PVBat\ 4$	$Q_{pv} - P_{Bat} - P_{pv}$	If V_{pcc} exceeds V_{crit} , Q_{pv} is provided by the PV system: $Q_{PV} = \begin{cases} o & if\ V_{PCC} < V_{thres} \\ -Q_{PV} & if\ V_{PCC} > V_{thres}\ and\ \lvert Q_{PV}\rvert\ < \lvert Q_{PV\,max}\rvert. \end{cases}$ If V_{pcc} is not reduced sufficiently, charging the battery with P_{pv} is applied once the -provision reaches its max. $Q_{pv\,max}$:	- Voltage dependent charging of the battery with focus on Q_{pv}provision

		$Q_{Bat,Ch} = \begin{cases} -P_{res} & if\ SOC < 1 and\ V_{PCC} < V_{thresa}\ and P_{res} > 0 \\ -P_{res} & if\ SOC < 1 and\ V_{PCC} > V_{thresa}\ and P_{res} > 0 and\ \lvert Q_{PV} \rvert < \lvert Q_{PV\ max} \rvert \\ -P_{PV} & if\ SOC < 1\ and V_{PCC} > V_{thres}\ and P_{res} > 0 and\ \lvert Q_{PV} \rvert = \lvert Q_{PV\ max} \rvert \\ 0 & if\ SOC = 1\ or\ P_{res} < 0 \end{cases}$	
$PVBat\ 5$	$P_{Bat}(P) - Q_{pv} - P_{Bat} - P_{pv}$	Battery charging starts after a certain difference P_{diff} of P_{res} is surpassed, as shown $P_{Bat,Ch} = \begin{cases} -(P_{res} - P_{diff}) & if\ SOC < 1 and\ V_{PCC} < V_{thres}\ and\ P_{res} > P_{diff} \\ -P_{res} & if\ \ SOC < 1 and\ V_{PCC} > V_{thresa}\ and P_{res} > 0\ and\ \lvert Q_{PV} \rvert < \lvert Q_{PV\ max} \rvert \\ -P_{PV} & if\ \ SOC < 1\ and\ V_{PCC} > V_{thres}\ and P_{res} > 0\ and\ \lvert Q_{PV} \rvert < \lvert Q_{PV\ max} \rvert \\ 0 & if\ SOC = 1\ or\ P_{res} < 0 \end{cases}$	- P_{pv}-peak oriented and voltage dependent charging of the battery

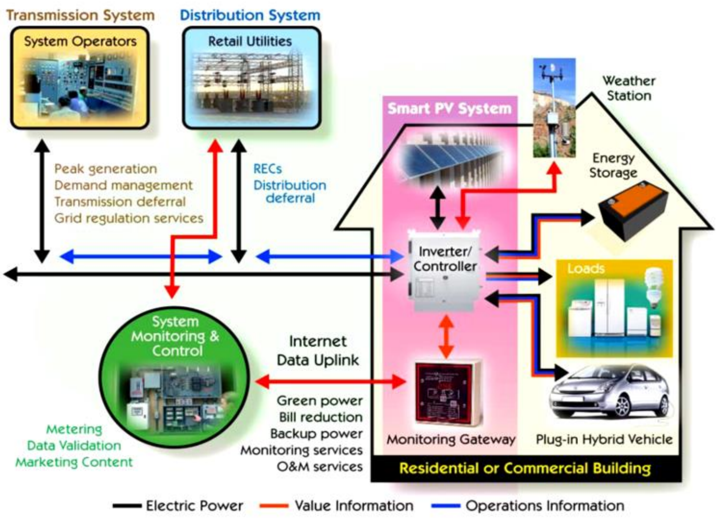

Figure 17. The solar energy grid integration system integrated with advanced distribution systems [71].

Advanced PV system technologies include inverters, controllers, related balance-of-system, and energy management hardware that are necessary to ensure safe and optimized integrations, beginning with today's unidirectional grid and progressing to the smart grid of the future [71]. Fig. 17 show the smart PV system integrated with the advanced distribution system.

Integrating PV system based on the transmission system operators (TOSs) are required to maintain a continuous balance between generation and consumption. Also to increase the PV network penetration to the grid to covering the substantial amount of the demand by fully integrated into the system security management [72]. TOSs responsible for collect the data and the information's about the amount of the distribution energy resources DER units on-line (including PV and other DERs units) where required for estimating power injections at boundaries between the TOS and DOS grid.

The integration of the PV arrays for distributed generation DG application by identifying a combination of the building that will maximize solar energy and minimize system variability was presented in [73]. It proposed optimal model to choose suitable rooftop for PV integration based on Markowitz mean-variance portfolio selection model. The result calculated by Mixed Integer Quadratic Programming (MIQP).

The main challenges of integration PV system with the grid are mentioned in following point [74].

a) The design of the main network.
b) Energy storage development and technology.
c) Communication development.
d) Advanced Metering Infrastructure.
e) Information security.

The significant contribution of this paper [75] is mentioning some of integrate challenges of PV systems with the grid as following:

a) Fitful generation of solar PV due to naturel resource: is requiring to dispatch and scheduling.
b) Transmission lines issue: required planning and system studying for Transmission expansion to support increasing level of solar generation.

c) Distribution system: due to increase penetration of the PV system in the grid considered high challenge on the existing distribution infrastructure.
d) Energy Storage Integrate: usually use for Standalone of PV system.

A. Power Management

The control of integrate PV inverter to AC grid based on the strategies of power management has been reported [76]. To clarification the impact of high power injection from PV to the AC grid a setup of smart grid has been being developed as in Fig. 18.

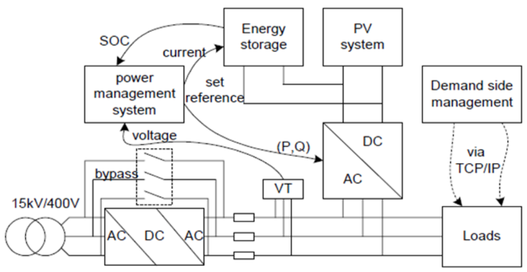

Figure 18. Set-up of smart grid [76].

The scenarios of the power management are as following points.

a) The ratio between power injection level and S.C power level is increase then the allowed slop change of power injection into grid will decreased.
b) If the voltage on the primary side of the transformer is decrease then the allowed slope change of power injection in to the grid can increase.
c) The (SOC) state of charge in the energy storage will slowly be adjusted as the function of time during each day.

In brief the strategies of power management of the DC/AC inverter can guarantees high power quality for the system, when high power injection from PV into the grid [76].

The United State Department of Energy Renewable Systems Interconnections (RSI) in 2008 studied the identified a list of grid integration issues that need to be addressed in order to accommodate high level of distributed generation systems, particularly distributed PV systems. [77] These contain:

a) Voltage regulation.
b) System planning.
c) Unintentional islanding.
d) Protection coordination.

The technologies in inverter and control with integrated smart grid functionalities will help coordinate between PV generation and the operation of other grid assets.

References

[1] P. Denholm, *et al.*, "Bright future: Solar power as a major contributor to the U.S grid," *IEEE Power and Energy Magazine*, vol. 11, no. 2, pp. 22-32, 2013.

[2] J. V. Appen, M. Braun, T. Stetz. K. Diwod, and D. Geibel, "Time in the sun: The challenge of high PV penetration in the German electric grid," *IEEE Power and Energy Magazine*, vol. 11, no. 2, pp. 55-64, 2013.

[3] K. Ogimoto, I. Kaizuka, Y. Ueda, and T. Oozeki, "A good fit: Japan's solar power program and prospects for the new power system," *IEEE Power and Energy Magazine*, vol. 11, no. 2, pp. 65-74, 2013.

[4] O. Ozdal and I. Hakki, "A new energy management technique for PV/wind/grid renewable energy system," *International Journal of Photo Energy*, pp. 1-19, 2015.

[5] N. Stecky, "Renewable energy for high-performance buildings in New Jersey: Discussion of PV, wind power, and biogas and New Jersey's incentive programs," *ASHRAE*, vol. 110, pp. 602-610, 2004.

[6] Galvin Electricity Initiative. Understanding Microgrid. [Online]. Available: http://www.galvinpower.org/sites/default/files/documents/Understanding

[7] E. Khalil, "The role of solar and other renewable energy sources on the strategic energy planning: AFRICA's status & views," *ASHRE Transaction*, vol. 118, no. 1, pp. 64-72, 2012.

[8] M. Mann. (2011). National renewable energy laboratory. US Department of Energy. [Online]. Available: http://www.nrel.gov/analysis/sustainability_ analysis.html

[9] N. Scarlat, J. Dallemand, F. Monforti, and M. Banja, "Renewable energy policy framework and bioenergy contribution in the European Union – An overview from national renewable energy action plans and progress reports," *Renewable and Sustainable Energy Reviews*, vol. 51, pp. 969-985, 2015.

[10] R. Kardooni, S. Binti, and F. B. Kari, "Renewable energy technology acceptance in Peninsular Malaysia," *Energy Policy*, vol. 88, pp. 1-10, 2016.

[11] K. S. Krishna and K. S. Kumar, "A review on hybrid renewable energy systems," *Renewable and Sustainable Energy Reviews*, vol. 52, pp. 907-916, 2015.

[12] S. Y. Park, B. Yun, D. H. Lee, and D. G. Choi, "An analysis of the optimum renewable energy protfolio using the bottom-up model: Focusing on the electricity generation sector in South Korea," *Renewable and Sustainable Energy Reviews*, vol. 53, pp. 319-329, 2016.

[13] S. A. Alavi, A. Ahmadian, and M. Aliakbar-Golkar, "Optimal probabilistic energy management in a typical miro-grid based-on robust optimization and point estimate method," *Energy Conversion and Management*, vol. 95, pp. 314-325, 2015.

[14] H. Kondziella and T. Bruckner, "Flexibility requirements of renewable energy based electricity systems: A review of research results and methodologies," *Renewable and Sustainable Energy Reviews*, vol. 53, pp. 10-22, 2016.

[15] P. Neto, O. Saavedra, and L. Riberio, "Optimization of electricity generation of a tidal power with reservoir constraints," *Renewable Energy*, vol. 81, pp. 11-20, 2015.

[16] P. Steimer, "Power electronic, a key technology for energy efficiency and renewables," in *Proc. IEEE Energy 2030 Conference*, Atlanta, GA, USA, November 17-18, 2008.

[17] G. N. Tiwari and M. K. Ghosal, *Renewable Energy Resources: Basic Principles and Applications*, Alpha Science International Limited, 2005.

[18] H. Lund, "Renewable energy strategies for sustainable development," *Energy*, vol. 32, no. 6, pp. 912-919, 2007.

[19] K. Blok, "Enhanced policies for the improvement of electricity efficiencies," *Energy Policy*, vol. 33, no. 13, pp. 1635-1641, 2005.

[20] N. Lior, "Advanced energy conversion to power," *Energy Conversion and Management*, vol. 38, no. 10, pp. 941-955, 1997.

[21] N. Lior, "Thoughts about future power generation systems and the role of exergy analysis in their development," *Energy Conversion and Management*, vol. 43, no. 9, pp. 1187-1198, 2002.

[22] N. Afgan and M. Carvalho, "Multi-Criteria assessment of new and renewable energy power plants," *Energy*, vol. 27, no. 8, pp. 739-755, 2002.

[23] N. Afgan and M. Carvalho, "Sustainability assessment of hydrogen energy systems," *International Journal of Hydrogen Energy*, vol. 29, no. 13, pp. 1327-1342, 2004.

[24] N. Duic and M. G. Carvalho, "Increasing renewable energy sources in island energy supply: Case study Porto Santo," *Renewable and Sustainable Energy Reviews*, vol. 8, no. 4, pp. 383-399, 2004.

[25] A. Y. Al-Hasan, A. A. Ghoneim, and A. H. Abdullah, “Optimizing electrical load pattern in kuwait using grid connected photovoltaic systems,” *Energy Conversion and Management*, vol. 45, no. 4, pp. 483-494, 2004.
[26] K. Ro and S. Rahman, “Control of grid connected fuel cell plants for enhancement of power system stability,” *Renewable Energy*, vol. 28, no. 3, pp. 397-407, 2003.
[27] F. Garcia and C. Bordons, “Optimal economic dispatch for renewable energy microgrids with hybrid storage using model predictive control,” in *Proc. 39th Annual Conference of the IEEE Industrial Electronics Society*, 2013, pp.7932-7937.
[28] M. T. Iqpal, “Simulation of small wind fuel cell hybrid energy system,” *Renewable Energy*, vol. 28, no. 4, pp. 511-522, 2003.
[29] H. Lund, “Large scale integration of optimal of PV, wind and wave power into the electricity supply,” *Renewable Energy*, vol. 31, no. 4, pp. 503-515, 2006.
[30] N. Raval and A. Kumar, “Historic development, current technologies and potential of nanotechnology to develop next generation solar cells with improved efficiency,” *IJRED*, vol. 4, no. 2, pp. 77-93, 2015.
[31] P. Breez, *Power Generation Technologies*, Elsevier, 2005.
[32] Affordable solar. [Online]. Available: http://www.affordable-solar.com/Learning-Center/Solar-history
[33] A. Kellas, “Utilizing the solar energy for power generation in Cyprus,” in *Proc. MEDPOWER*, 2012, pp. 1-7.
[34] M. Abdel-Salam, A. Ahmed, A. El-kousy, K. Sayed, M. Amery, M. Swify, and M. Khalaf, “On the design and operation of a standalone residential PV system in Egypt,” in *Proc. IEEE International Conference on Clean Electrical Power*, Alghero, Italy, June 2013, pp. 659-664.
[35] F. Bustos, A. Toledo, J. Contreras, and A. Fuentes, “Sensitivity analysis of a photovoltaic solar plant in Chile,” *Renewable Energy*, vol. 87, pp. 145-153, 2015.
[36] B. M. Sharma and K. Sahay, “A comprehensive survey of maximum power tracker techniques for photovoltaic system,” *I-Manager's Journal on Electrical Engineering*, vol. 8, no. 1, pp. 39-55, July-September 2014.
[37] T. Kobayakawa and T. C. Kandpal, “Analysis of electricity consumption under a photovoltaic micro-grid system in India,” *Solar Energy*, vol. 11, pp. 177-183, 2015.
[38] Y. Chen and K. M. Smedley, “NNA cost-effective single –Stage inverter with maximum power point tracking,” *IEEE Transaction on Power Electronics*, vol. 19, no. 5, pp. 1289-1294, 2004.
[39] A. A. Elbaset and M. S. Hassan, “Design and implement of 100KW rooftop grid connected PV system: Faculty of engineering as a case study,” in *Proc. 3rd International Conference on Energy System and Technologies*, Cairo, Egypt, Feb. 16-19, 2015, pp. 71-83.
[40] Diagram of the possible components of a photovoltaic system. [Online]. Available: https://en.wikipedia.org/wiki/Photovoltaic_system#/media/File:From_a_solar_cell_to_a_PV_system.svg
[41] [Online]. Available: http://www.pvmagazine.com/news/details/beitrag/renesola-achieves-record-third-quarter-results plans.
[42] T. P. Sahu, T. V. Dixit, and R. Kumar, “Simulation and analysis of perturb and observe MPPT algorithm for PV array using ĊUK converter,” *Advance in Electronic and Electric Engineering*, vol. 4, no. 2, pp. 213-224, 2014.
[43] R. Candela, E. R. Sanseverino, P. Romano, M. Cardinale, and D. Musso, “A dynamic electrical scheme for the optimal reconfiguration of PV modules under non-homogeneous solar irradiation,” *Applied Mechanics and Materials*, vol. 197, pp. 768-777, 2012.
[44] X. Wang, H. Cheng, D. Wang, W. Guo, and H. Cheng, “Research of grid-connected operation control of PV cells in microgrid,” *Applied Mechanics and Materials*, vol. 291-294, pp. 2063-2067, 2013.
[45] F. A. Almansour, “The effectiveness of small scale photovoltaic PV system design and cost analysis simulation on Saudi Arabian economy,” M.S. thesis, North Carolina Agricultural and Technical State University, 2013.
[46] O. H. Mohammed, Y. Amirat, M. Benbouzid, G. Feld, T. Tang, and A. A. Elbaset, “Optimal design of a stand-alone hybrid PV/fuel cell power system for the city of Brest in France,” *International Journal on Energy Conversion*, vol. 2, no. 1, pp. 1-7, 2014.
[47] H. H. EL-Tamaly and A. A. Elbaset, “Modeling and simulation of photovoltaic/wind hybrid electric power system interconnected with electrical utility,” in *Proc. IEEE 12th International Middle-East Power System Conference*, 2008, pp. 645-649.
[48] H. H. EL-Tamaly and A. A. Elbaset, “Optimal operation of photovoltaic/utility grid interconnected electric power system using neural network,” in *Proc. IEEE 11th International Middle-East Power System Conference*, 2006.
[49] H. H. EL-Tamaly and A. A. Elbaset, “Performance and economic study of interconnected PV with electric utility accompanied with battery storage,” in *Proc. Eleventh International Middle East Power Systems Conference*, 2006, pp. 328-333.
[50] DOE Micro-Grid Workshop Report, Office of Electricity Delivery and Energy Reliability Smart Grid R&D Program, August 2011.
[51] M. S. Khan and M. R. Iravani, “Supervisory hybrid control of a micro grid system,” in *Proc. IEEE Electrical Power Conference*, 2007, pp. 20-24.
[52] A. N. Dey and P. Basak, “Microgrid from an Indian perspective,” in *Proc. IEEE 9th International Conference on Intelligent Systems and Control*, 2015.
[53] S. Chowdhury, S. P. Chowdhury, and Peter Crossley, “Microgrid and active distribution network,” in *Microgrids and Active Distribution Networks*, IET Digital Library, 2009.
[54] “Microgrids: An assessment of the value opportunities and barriers to the deployment in New York State,” New York State Energy and Research Development Authority, Sept. 2010.
[55] K. Ravindra and P. P. Tyer, “Decentralized demand-supply matching using community microgrids and consumer demand response: A scenario analysis,” *Energy*, vol. 26, pp. 32-41, March 2014.
[56] R. H. Lasseter and P. Paigi, “Microgrid: A conceptual solution,” in *Proc. IEEE 35th Annual Power Electronics Specialists Conference*, 2004, pp. 4285-4290.
[57] A. Jeevan and B. M. Imran, “Microgrid inverter operation in three phase grid-connected and disconnected modes,” *International Journal of Engineering Science and Technology*, vol. 5, no. 11, pp. 1817-1823, Nov. 2013.
[58] R. Gholami, M. Shahabi, and M. R. Haghifam, “An efficient optimal capacitor allocation in DG embedded distribution networks with islanding operation capability of micro-grid using a new genetic based algorithm,” *International Journal of Electrical Power and Energy Systems*, vol. 71, pp. 335-343, 2015.
[59] T. Kobayakawa and T. C. Kandpal, “Analysis of electricity consumptions under a photovoltaic micro-grid system in India,” *Solar Energy*, vol. 116, pp. 177-183, 2015.
[60] M. Rekik, A. Abdelkafi, and L. Krichen, “A micro-grid ensuring multi-objective control strategy of a power electrical system for quality improvement,” *Energy*, vol. 88, pp. 351-363, 2015.
[61] R. Carbone, “Grid-Connected photovoltaic systems with energy storage,” in *Proc. International Conference on Clean Electrical Power*, 2009, pp. 760-767.
[62] J. Stuchly, S. Misak, and L. Prokop, “A simulation of energy storage system for improving the power system stability with grid-connected PV using MCA analysis and lab view tool,” *Power Engineering and Electrical Engineering*, vol. 13, no. 2, pp. 127-136, 2015.
[63] K. C. Divya and J. Ostergaard, “Battery energy storage technology for power systems: An overview,” *Electric Power Systems Research*, vol. 79, no. 4, pp. 511-520, 2009.
[64] D. Shively, J. Gardner, T. Haynes, and J. Ferguson, “Energy storage methods for renewable energy integration and grid support,” in *Proc. IEEE Energy 2030 Conference*, Atlanta, 2008, pp. 1-6.
[65] W. F. Pickard, A. Q. Shen, and N. J. Hansing, “Parking the power: Strategies and physical limitations for bulk energy storage in supply–demand matching on a grid whose input power is provided by intermittent sources,” *Renewable and Sustainable Energy Reviews*, vol. 13, no. 8, pp. 1934-1945, 2009.
[66] H. Ibrahim, A. Ilinca, and J. Perron, “Energy storage systems: Characteristics and comparisons,” *Renewable and Sustainable Energy Reviews*, vol. 12, no. 5, pp. 1221-1250, 2008.
[67] C. D. L. Cruz, M. B. Lema, X. D. T. Garcia, and P. Roncero-Sanchez, “Energy storage integration with renewable energies:

The case of concentration photovoltaic systems," *Hdb. Env. Chem.*, vol. 34, pp. 73-94, 2014.
[68] B. Droste-Franke, P. B. P. C. Rehtanz, D. U. Sauer, J. P. Schneider, M. Schreurs, and T. Ziesemer, "Balancing renewable electricity," *Ethics of Science and Technology Assessment*, vol. 40, 2012.
[69] S. Nykamp, A. Molderink, J. L. Hurink, and G. J. M. Smit, "Storage operation for peak shaving of distributed PV and wind generation," *IEEE Transaction on Smart Grid*, pp. 1-6, 2013.
[70] J. Appen, T. Stetz, M. Braun, and A. Schmiegel "Local voltage control strategies for PV storage systems in distribution grids," *IEEE Transactions on Smart Grid*, vol. 5, no. 2, pp. 1002-1009, March 2014.
[71] C. Whitaker, J. Newmiller, M. Ropp, and B. Norris, "Renewable systems interconnection study: Distributed photovoltaic systems design and technology requirements," Sandia Report, SAND2008-0946 P.
[72] C. Coujard, A. Vafeas, and S. Galant, "Grid integration of PV systems: Could the electric network become the bottleneck?" TECHNOFI, 2008.
[73] X. Li and O. A. Omitaomu, "Optimal solar PV arrays integration for distributed generation," in *Proc. Industrial and System Engineering Research Conference*, 2012.
[74] S. R. Akhter, K. Ahmed, S. Hussan, and A. Khalid, "Integration of smart grid with the existing power network of Bangladesh: Power grid and renewable power generation," in *Proc. IEEE ISGT*, 2013.
[75] T. Kaur, "Solar PV integration in smart grid – Issue and challenges," *International Journal of Advanced Research in Electrical*, *Electronic and Instrumentation Engineering*, vol. 4, no. 7, 2015.
[76] Y. Cheng, "Impact of large scale integration of photovoltaic energy source and optimization in smart grid with minimal energy storage," in *Proc*. *IEEE International Symposium on Industrial Electronics*, 2010, pp. 3329-3334.
[77] B. Kroposki, *et al.*, "Renewable system interconnection: Executive summary," NREL Technical Report, NREL/TP-581-42292, 2008.

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