Smart Grid Technologies

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***Abstract*- The smart grid enables power system for duplex power flow and information. The demand of electricity of 21st century is increasing day by day, which cannot be overcome by the ill-suited 20th century power grid. The world is facing the most challenging issues in terms of energy supply, which is because of certain factors such as growing population, more homes and factories as a result of which the energy demand in every part of country has increased. When the ordinary grid is shifted to smart grid, it improves electricity, supply method and usage of electricity to commercial, industrial and residential consumers on large scale. Due to intelligent and smart operation it saves billions of dollars. Smart grid ensures high reliability by intelligent penetration of renewable energy resources, where required. This paper explains economic benefits, operation, important components and electronic information of smart grid. It also focuses on problems in smart grid, as well as state of the art solution proposed by the researcher.**

Keywords: smart grid, smart protection systems, reliability

I. INTRODUCTION

For supplying electrical energy from the producers to the consumers, an interconnected network is required, which is called electrical grid. It consists of three components. More than 60% of global power through steam turbine is produced by power generation system, which is the process of producing electrical power. For transferring power from power station to demand center power transmission system are used. Individual consumers are connected through power distribution system. All of these power systems plays an important role in transferring power from generation system to the consumer. But there are certain problems and limitations which are associated with power grid. i.e. the efficiency of power grids is reduced due to work of enemies or to some natural disaster. It has been observed that most of our power grids are in old age. As the power grids consist of many components so most of our electrical components are 50 to 100 years old. So the aged part needs to be replaced. The old power grid also faces financial problem, as for repair of different power grid equipment's and up gradation trillions of dollars are spent. Different power companies keep on using the aged equipment's because they cannot afford to replace the aged power system equipment's, which results in the occurrence of faults on different power plants. As the existing power grid is aged, so this results in increase in number of blackouts in a particular area. These electrical outages may be due to technical and hardware failure, environmental incidents or human errors. The traditional grid is electromechanical so fault can easily occur. In traditional grid the flow of power is unidirectional. This electrical grid has few sensors and is monitored and restored manually. The electrical grid has limited control. Foreign hackers/cyber-attack can have trickled our power station in order to find different ways so that the power supply can be cancelled or cutoff for a particular area. The reliability and efficiency of existing power grid also decreases due to occurring of faults in real time on power generation, transmission and distribution because there is a fluctuation in the phase and voltage of power system . The smart grid offers significant reduction in electricity cost by increasing power system reliability though integrated VAR compensation, intelligent and remote metering, and integration, which results in direct economic benefits, reliability improvement, CO_2 emission reduction, indirect economic monitory benefits, and costumer choice benefits. There are four important drivers which influence benefits. The above-mentioned capabilities of smart grid are the reasons due to which traditional grid is needed to be upgraded to smart grid. Solution to said reasons are economic dispatch, improving power reliability be interconnecting distributed generations to reduce reserve capacity, optimizing electricity utilization and management of backup generators for peak load, enhancing capacity of existing power system network by establishing overlapping zones of protection, improving pliability to the continuous and short term disruption, establishing the algorithm which can forecast fault and provide schedule maintenance accordingly, facilitating expanded deployment of renewable energy generation facility to ensure indirect economic benefits, enabling electric vehicles and reducing dependency on thermal generation to reduce CO_2 emission, increasing direct monitory benefits by decreasing fuel consumption by reducing extra generation in off peak hours, providing storage capability to cater emergency need, and communication with customers regarding services and billing It shows the problems and growth associated with smart grid. Here implementation of smart grid is taken as case study [1].

The demand of the consumer can be met as smart grid has the capability to store electrical energy, which can be supplied during peak hours. Reliance on operators is reduced due to adaptively of smart grid because if there is a change in the conditions it responds rapidly through different sensors and communication technologies. For example, potential outages can be identified by using techniques of smart grid. By using communications of real time and function of control, a smart grid is integrated. Smart grid provides customers and market interaction. The availability and efficiency of smart grid makes the grid station secure from attacks and naturally occurring disturbances. All the needs and concerns of the consumers' needs to be addressed by the electrical energy system of the future in order to have a smarter, reliable and efficient power grid system. The enabling infrastructure are the second and third layer that smarter the existing energy and power infrastructure. In order to obtain a system which is clean, sustainable, efficient, reliable, safe and secure, smart grid is a power system in which the communication technologies is cyber secure and generation transmission, distribution and consumption are computational intelligence. Black outs are the conditions for a power system when the demand of electrical energy is more than the supply, which is the major problem for a power station without smart

grid technologies. The gap between the demand and supply of power should be as low as possible and should be balanced, which can be obtained by an intelligent and more efficient grid such as smart grid. Smart grid is fully automated grid for delivery of electricity and facilitation of users. Smart grid has been divided into six domains i.e. consumer service provider, market, operations, generation transmission and distribution Demand side management Demand response programs, distributed generation, and technical issues are taken in to account. Here smart grid technologies has also been explained [2].

II BENEFITS OF SMART GRID

The smart grid addresses the following functionalities.

a) It Increases the safety and operational flexibility of the power system through control and communication across the power system.
b) Energy conservation is better due to which consumer participates actively.
c) Power system safety is ensured by cyber secure communication system.
d) Long term sustainability is obtained by better utilization of existing assets.
e) The cost of energy and losses is controlled by optimized energy flow.
f) Overall cost of energy is decreased by management of distributed generation and energy storage.
g) The global climate change is addressed by integration of renewable energy resources.
h) Grid conditions are monitored in real time.
i) New generating power plants can be connected to the grid due to its plug and play ability
j) Isolates the faulty zones from healthy zones which reduce the chances of blackouts.
k) Huge amount of solar and wind power can be managed through its enhancing capability.

III. DISCUSSION/SOLUTION

End to end system efficiencies become more important when more intelligent devices are attached with smart grid. The rapid rising number of urban cities worldwide has caused the demand for sustainable energy. In 2014, the world's populations living in urban areas is 54 percent and by 2050 the numbers can rise up to 70 percent. So in order to address the increasing demand for sustainable energy smart grid is considered as one of the best energy. The consumer everywhere around the world wants his electricity bill to be reduced as much as possible. He also wants to use electricity 24 hours' day and night. Since today's power grid are becoming overloaded due to increase in maximum demands of different consumers, so smart grid is the best choice in overcoming these problems. There are various techniques for load balancing in smart grid. For smart grid infra-structure communication system is the important component. Generation of data from many smart grid applications will be adjusted for its analysis. Due to integration of application of smarter electricity, grid infra-structure with advanced technology will be used in smart grid in order to facilitate the consumers. The faraway consumer is served by the today's power system, which is a single way system of distribution and transmission power system. As the distributed sources in case of smart grid power generation power which flows across a network based grid so this future grid necessarily be a two-way communication system. Distribution level protection and automation techniques are explained with examples [3].

Important focused area for research community is the application of modern information and communication technologies in smart grid networks. Advance metering infra structure (AMI) and new demand management policies are the main steps towards energy efficiency in distribution networks. By providing different economic incentives for shifting peak load hour to off peak hour loads the consumers are encouraged by the DSM programs. Direct load control (DLC) were DSM programs which was a unidirectional communication. For high power consumption consumers, DLC is the most useful method. Reduction of total energy cost is the main objective of DSM. Mixed integrated linear programming and game theory are the different optimization techniques but flexible nature of evolutionary algorithm (EA) gives the best results. By applying nature inspiration process the genetic algorithm (GA) shows appliances optimal schedule in a smart grid.In order to show the amount of electricity usage by the consumer, many exciting innovations are being developed. Reduction in the electricity bills and inter connection of green energy generation with conventional energy generation is becoming more and more necessary for the utilities. The electrical grid stations and the current conventional solution techniques are over loaded due to increase in maximum demand of the consumer day by day which makes the existing network more and more complex. So for an overall and better solution smart grid is the best choice.Due to influx of new competitors and a steady rise in customer churn, the energy sector has been experiencing a deregulation. Under the influence of digitization switching has also being accelerated. As a result, pressure is felt by energy providers on their prices and margins. To keep customers from churning is their top priority. As compared to new consumers, long-term customers with old contracts can be many times more valuable. Companies can manage their customer base more effectively and prevent churn by adopting automated algorithm-driven processes. By using time of use tariff, the consumer has the potential to save money. In order to ensure that the consumer is charged less for their bills the consumer is allowed to change their energy consumption. So in this way the smart grid technology empowers the consumers. Depending upon how much electricity is being used and at what, price real-time consumption will be displayed. So smart grid gives real time electrical energy consumption Smart grid communications and open research issues are discussed [4].

It is shown in report that by decreasing 1-volt consumption results in 1.24% reduction in cost per year, where implementation of VAR compensation reduces monthly bill by 11-32 US $. Keeping eye on electricity bill user can adjust his own comfort level.

IV. COMPARISION/RELATED WORK

Table 1 shows Comparison between different technologies [7]

Table 1: Comparison between different technologies

Technology	Data Rate	Applications	Spectrum	Range covered	Limitations
Zig bee	250 Kpbs	AMI,HAN	2.4 GHz to 920 MHz	30 to 50 m	Short range, Low data rate
WiMax	75 Mbps	AMI	2.5 GHz, 5.8 GHZ	10 to 50 km	Not wide spread
GPRS	170 kbps	AMI,HAN	900 to 1800 MHz	1 to 10 km	Low data rates
GSM	15 Kbps	AMI,HAN	900 to 1800 Mhz	1 to 10 Km	Low data rates
PLC	2 to 3 Mbps	AMI	1 to 30 Mbps	1 to 3 km	Noisy channel
3G	384 kbps to 2 Mbps	Demand response, AMI	1.92 to 1.98 GHz	1 to 10 km	Spectrum fees is costly

V SMART GRID MODEL

The basic and major components of smart grid are smart meters and distribution automation, which can be implemented independently but implementing them combine give more benefits. Smart metering infrastructure consist of current measuring instruments, data acquisition devices, and mechanism for receiving information and responding accordingly to the customer and utility. Smart meters are adopted due to more accuracy then mechanical meters because of tempering detection capability, remote meter reading, calculation of time varying rates, pre- payment option and remote connect disconnect capability. Distribution automation is the second most important component of smart grid which ensures high grid efficiency, reliability, and increasing the capacity to accommodate integrated electricity in a greater amount. It also provides the facility of integration of reactive power control, fault localization and isolation. The solution to each and every concern of the consumer is smart grid. The smart grid major components interaction is shown in figure 1. Smart meters, sensors, monitoring system and data management system are the important components of smart grid. (EMS) Energy Management system and (DPG) Distributed Power Generation) are the applications of smart grid. Communication infra-structure is important for all smart grid applications. For example, Home Area Network (HANs) is needed by home energy. Management system (HEMs). Similarly, Neighbor Area Network (NAN) requires communication between consumers and power stations. According to nature of application both wireless and wired are the two different types of communication which has its own merits and demerits. Equipment lower cost, low installation charges, and long area access are the merits of wireless technologies For power load balancing an interaction between power grid and data center is modeled as a two stage problem. So load balancing performance is improved by 12 % in terms of load index and electricity cost is reduced by 46 % on average. [5].

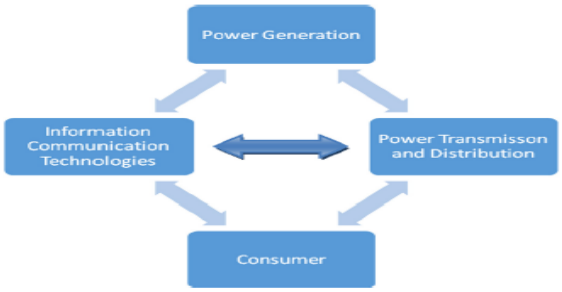

Figure 1: Smart grid major components interactions [5].

Smart Power Generation is defined as excellent operational mode flexibility, and outstanding dynamic response. Smart power generation is the ultimate solution in order to improve power system balancing capabilities.Importance of these challenges become urgent than ever before. But due to smart features of smart power transmission like digitalization, flexibility, intelligence, resilience, sustainability, and customization this problem can be overcome. The power from the bulk generation facilities to the power distribution systems is carried by energy-efficient transmission network. Between the transmission network, the bulk-generating stations, system operator, power market, and the distribution system communication interface exists. For applications such as transportation, aviation and robotics, it is an ideal power management approach. The key enablers for the smart distribution systems substation are automation and distribution automation. For future distribution systems, increasing use of distributed energy resources (DERs) will be an important feature. A new feature of the smart distribution systems is the information exchange between the distribution system operator and the customers for better operation of the power distribution system. Residential, commercial, and industrial customers are the three main types of consumers. Through demand side response in smart grids and in better operation of the distribution system by peak-load shaving, and emergency response, customers play a very important role. So the consumption is made smart by use of sensors, efficient appliances, renewable energy resources and smart meters. In order to reduce peak average ratio, the total energy cost, along with fast execution of algorithm, this research aim is to generic demand side management (G-DSM) model for both single and multiple scenarios [6].

Table 2 presents the benefits of smart grid capability per customer per year.

Table 2: Benefits by Smart Grid capability per customer per year

Capability	Direct economic benefits	Reliability improvement	CO_2 reduction	Indirect economic benefits	Customer choice benefits
VAR integration	11-32 $	Value not quantified	372 lbs	2.59 $	
Remote meter reading	13-24 $		Possible	Possible	
Renewable energy integration	Possible	Likely	likely		Yes
Fault localization		20.5%		40.14$	
Service outage management	1.8$	4.5%		8.82$	
Customer energy management	1.72$		34 lbs.	0.24$	Yes
Revenue assurance	3$				Yes

Pre-payment	19$		76 lbs.	0.53$	Yes
Total	101.5$	25%	592 lbs.	53$	Yes

VI. CONCLUSION

Advanced metering, robust communications capability, extensive automation, distributed generation, and distributed storage properties would be obtained due to smart grid. Through the integrated use of these technologies, smart grids will be able to provide high reliability and power quality, operate with lower cost, and offer customers a variety of service choices.

VII. FUTURE WORK

Smart grid technology is growing fast. Its contribution to energy efficiency and sustainability is undeniable. Up to 211 million metric tons of greenhouse gas emissions is reduced by smart grid and is much more reliable than a traditional grid.

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Improvement of Smart Grid operation using different techniques

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***Abstract*- China Southern power grid (CSG) control center and substation technical supporting system has been summarized in this research paper. As the power grid is complicated, so the grid sharing of data and operation development can have application of smart grid. Here operation smart systems (OSS) model has been proposed. So power system operation Cockpit (POC) has been taken as case study, which shows the important technologies [1].**

For a flexible, responsible power system grid, some academic literature has been arrived. Decarbonization, transportation, increasing electrical energy demand, is some drivers, which caused evolution. Electricity markets faces the following seven challenges mentioned in this research paper are Electricity grid technical and economic performance management, Time span scale, Resources of demand side, Power system activity, Infrastructure promotion, Jurisdiction to be respected, Operation of self-healing [2]. Distributed Renewable Energies (DREs) are used to decrease the fossil fuel consumption. In this research paper, the dispatch of DREs proposes two stages. For decentralized model, which is the main concern of the operator, the commitment of optimal unit, and time of use are considered in the first stage. For this purpose, swarm optimization algorithm and method of interior point are used. In order to minimize the export of electrical energy, a demand response of PHEVs is proposed in the second stage [3].

Keywords: China Southern power grid (CSG), Power system Operation Cockpit (POC), Distributed Renewable Energies (DREs)

I. INTRODUCTION

The development of the power grid is only possible because of smart grid. The power grid operation should be efficient and intelligent. The most complicated grid of the world is China Southern Power Grid (CSG), which has a maximum load of 120 GW in 2012. The safety of operation and grid stability are some of the serious problems associated with this power generation grid. For this purpose, Advanced Energy Management System (EMS) is applied. A flexible and standardized method for sharing of data is also applied in order to meet the next generation demand. So for this purpose a frame work with new system called operation smart system has been proposed in this research work [1]. Figure (1) shows renewable based smart micro grid

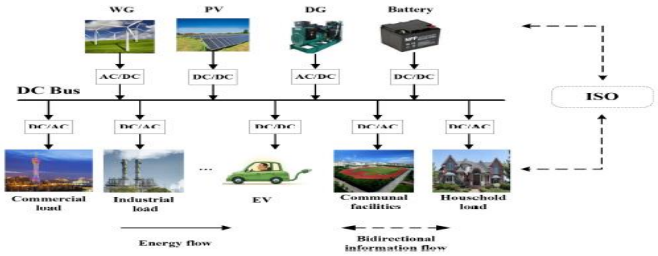


Figure 1: Renewable based smart micro grid

Centralized generation facilities controls the generation of the power grid, which was the assumption of traditional electrical system in order to serve the different loads. Economics and regulating measures the grid is controlled by such assumptions. So for this purpose, certain drivers are used out of which decarbonization is the first driver, which concerns with CO2 emissions. The second driver is the demand of electrical energy, which is rising in the developing countries. So it would be observed that about 4 % increase in electrical energy will result between year 2000 and 2030 approximately in developing countries. Decarbonization is also supported by electrified transportation, which is the third driver. The improved service quality, decrease in the price of electrical energy is promised by power markets deregulation which is the forth driver. In the electrical energy pattern of consumption, the consumer's active role is managed which is the last driver mentioned in this research paper. These five drivers make the power grid system more flexible, dynamic, and responsible due to which the efficiency of the existing power system will increased considerably [2]. The stack holder jurisdiction is shown in figure (2) below.

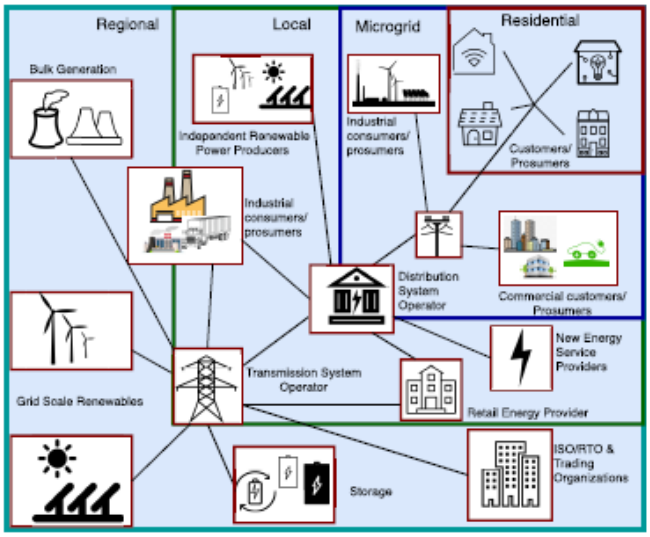


Figure 2: Stack holders Jurisdiction

High efficiency and most economical setup shows the superiority of the micro grid for supply of electrical energy because instead of using fossil fuel, the micro grids use distributed renewable energies (DREs). In order to decrease the transmission losses, the electrical energy is not transmitted over the long distances. So loads, energy storage systems (ESSs) and fuel generators combines to form a micro grid. Controlled

decentralization, ESS and DR programs are the different types of mechanisms to show the behavior of DREs. Here partial swarm optimization algorithm is used.

II. PROBLEMS

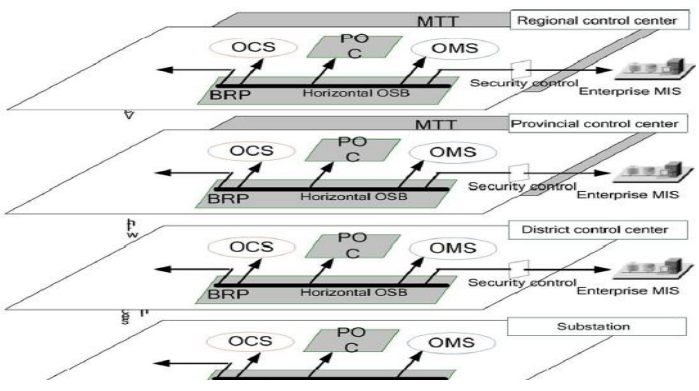
Chin Southern Power grid (CGS) has "Peak load of 120GW in 2012. Main challenges for the safety operation and stability of the grid are complicated long distance different types of faults in power system. So complicated power system has to monitor through management system of energy. In order to establish a sound response without the support of adequate data, this data cannot be shared with other systems [1].

Decarburization is the first driver about rising CO_2 emission is the main concern of the world. Rising electricity demand is the second driver. About 4 % each year between 2000 and 2030 increase in electricity demand in developing countries has been reported. Decarburization effects are the third driver of electrified transportation. However, reduction in price of electrical and service quality promises social welfare. The electric power grid countries to evolve distribution power system in order to develop electricity market [2].

Micro grids have superiority for Electrical energy supply in the best way. First instead of transmission fossil fuel, distributed Renewable energies are consumed by micro grids and second for long distance transmission of electricity which reduce transmission losses are combined with renewable energy generates to form a micro grid. Renewable energy generating proportions are continuously increasing which makes a micro grid uncertain. As a result of which the micro grid operation cost gains enhancement. In order to reduce the total electricity cost charging and discharging profile adjustment is done [3].

III. FINDING

With the increasing development in the grid station, it has been observed that member and technical supporting system are increasing. Also set of system are 120 and control center of CSG are 5. In the control center and substation, the operation of the power station is required. As the consumer demand is increasing day by day so the continues supply of electrical energy is not possible. Without support of an integrated architecture, there would be an increase in the investment of new power stations which results in the diversity of the system. The advanced ICTs are not well used in the present power system. [1]. The operation smart system overall architecture used in the research paper is shown in figure (3) below.



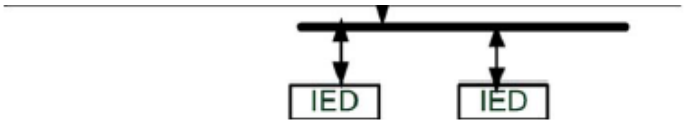


Figure 3: OS2 Over all architecture

The system operation and management get benefits from installing new equipment at the power system. Some of the problems associated with this are complex equipment and its complex function. In order to reduce the gap between the supply and demand of electricity the author has studied a new technology [2]. Table 1 shows a balance between generation and demand of electrical energy.

Table 1: balance between generation and demand of electrical energy.

	Generation	Demand
Dispatchability	• Low – Wind, Solar, Run of River Hydro • Medium – Hydro, Solar CSP • High – Thermal Units	• Low – Lighting • Medium – HVAC, Commercial buildings • High – Industrial production
Flexibility/ Ramping (Thermal Energy to Work ratio)	• Low – Nuclear & Coal • Medium – CCGT • High – Hydro, GT, IC	• Low – Chemical, petrochemical, metals • Medium – HVAC, Commercial Buildings, Refrigerators • High – Heaters, kettles, EV battery
Forecastability	• Low – Solar PV • Medium – Wind generation • High – All dispatchable generation	• Low – N/A • Medium – lighting, cooking, hair drying • High – Scheduled Industrial Production
Stability	• Synchronous Generators w/ AVR • Wind Induction Generators w/ low voltage ride through • Solar PV w/ power electronics	• Synchronous motors in HVAC applications • Induction Motor appliances with active harmonic control • EV's w/ power electronic based control
Resilience	• Recovery from generator faults • Intentional switching of generators	• Recovery from load shedding • Intentional switching of loads
	• Intentional and Unintentional Switching of Lines	

In this paper, the research contributions are as follows.

a) While decreasing the operation cost the algorithm known as decentralized algorithm is used. So the maximum revenue for the operator is obtained by reducing the electricity consumption.

b) For forecasting the imbalance, the electrical energy supply and demand should be reflected more accurately.

c) The mechanism represented by the author is more flexible and economical for micro grid consumers.

d) According to electrical energy supply and demand charging, PHEVs should be used as DR source.

e) Micro grids become smarter due to exchange of two-way information between supply and demand of electrical energy [3].

IV. DISCUSSION

Standard development for new built system and upgrading for existing system is the basic principle for the technical standard. According to such standard, step by step up gradation of the existing power system will be done. Around different systems, data will be easily shared. On existing system, it was built. The OSB adapters were developed according to the standard data modeling. There are four models i.e. getting the data of the real time, then collecting it through an algorithm and display the result is the function of KPI engine and dash board module [1].

Significant scalability and distribution is required by technology of smart grid. Smart grid technologies cannot be accommodated by physical good infrastructure. The local grid code may be

adhering with the power grid physical device. The solution of global behavior is demonstrated by MAS. Coordination of agents with control decision in real time events in the grid must be monitored. So a low as well as a high level of coordination is required. Congestion increases wait time at charging stations. Transportation and electricity are the two networks which have been acknowledged. Out of total electrical energy produced, 33 % is consumed by system of production. Which results in 36 % of CO_2 emissions, due to growing global emissions, energy efficient methods are adopted by most of the power plants in the word. The electrical power competes with the district heating and cooling. An important role played by natural gas resources is the gas turbine power plant stabilization. Because as compared to coal and oil fired facilities, generating plants operated by gas has less carbon emission percentage [2].

There are two stages for the operation mechanism. Decentralized optimization model is employed in the first stage. For forecasting of electrical energy, a method of decision making is applied in the second stage. It has been observed that owner of the proposed micro grid is the operator, who's duty is to minimize the electricity import and maximize the profits. The micro grid profit and DREs consumption efficiency is the main aim of this research. Decision method is proposed after forecasting the amount of electrical energy imported and exported [3].

V. CONCLUSION

Satisfying the increasing needs of the present world cannot be delivered by the traditional grid station without upgrading it. Safe, economic, qualified and environmental friendly are the feature associated with operating a smart grid system, which is a new frame work to be designed [1].

The long term challenges are significant due to distributed energy resources. This work identifies several long term drivers. In promoting long term reliability, an important role is played by Demand Side Resources (DSRs). Enhancing the integration of DSRs will occur due to the control of distributed system. Enabled by distributed control, a smart grid must be able to heal itself through automatic sensors [2].

In this research paper, for market based operation an operating mechanism for two stage has been designed. Taking into account the inter mitten outputs of DRGs, first stage decentralized optimization is proposed. Here the load and operator are considered so that the benefits can be obtained [3].

VI. FUTURE WORK

The proposed models can be useful for the implementation at different stakeholder levels in Pakistan. During the year 2016-17, development with higher growth rate of 9.05 % is observed in Pakistan construction sector. So by implementing the proposed models mentioned in the research papers, the overall cost of energy will be decreased by management of distributed generation and energy storage. The safety and operational flexibility of the power system through control and communication across the power system will be obtained. The Power system safety would be ensured by cyber secure communication system. A Long term sustainability would be obtained by better utilization of existing assets.

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