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Analysis of Demand Side Management of Distribution Systems

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Abstract - *Demand side management (DSM) provides power systems with the opportunity to supply electricity to the customers more efficiently and reliably. In a smart grid incorporating automated control and distributed energy systems, an effective DSM can alleviate the peak load and shift part of the demand to off-peak hours. A different DSM technique like alternate energy sources, load scaling and valley filling is implemented in an IEEE 33 bus system. The alternate energy source used here is Distribution generators and batteries. The load shifting is done for different percentages of load and valley filling is done for different cases. The improvement of voltage profile and losses for all the DSM cases is compared with the IEEE 33 bus system. The efficiency of different DSM techniques is analyzed by considering the losses in each technique. Effectiveness of the proposed system is tested on IEEE-33 bus systems using Dig Silent power factory Software tool.*

***Key Words*: Demand Side Management, Load Shifting, Renewable Energy Sources, Distribution Generators, DigSilent Software, Voltage Profile.**

1. INTRODUCTION

A micro grid is a group of interconnected loads and distributed energy resources that acts 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 grid-connected or separate mode. Some of the disadvantages of micro grid are Voltage, frequency and power quality should be at acceptable limits. The limitations of micro grid can be overcome by Demand Side Management (DSM) techniques. This project implements the DSM techniques in the distribution Systems and the results are analyzed.DSM is analysed using power flow analysis. They are necessary for designing, operation, economic scheduling and exchange of power among utilities. Transmission line is characterized by resistance, inductance, and capacitance. This will result in losses. These losses cannot be eliminated but it can be reduced. Voltage collapses generally happens on power systems that are heavily loaded, faulted and/or have reactive power shortage. In recent years, deregulation of electricity has emerged for its huge demand's techniques are being played a vital role for better utilization of the existing power system with the increased demand. On the other hand, transmission and distribution orientation has become more severe due to the lack of proper arrangement. The major power loss occurs for system loss which is increasing day by day around the world and has emerged as a challenge for the developing countries to run with limited resources. To minimise this transmission power loss and ensure optimal power flow, DSM is introduced in power system. Terminal voltages and voltage angle of different buses can be controlled by DSM techniques in a fast and effective way.

In automated control and distributed energy systems, an effective DSM can alleviate the peak load and shift part of the demand to off-season hours. This paper evaluates the impact of DSM on reliability of automated power distribution systems [1]. This work aims to develop a methodology to perform the active demand side management for households in smart grids, which contain distributed solar photovoltaic generation and energy storage. Such methodology outcomes a decision-making system that manages the battery aiming to reduce the consumer electricity cost [2]. This paper makes use of different energy sources like solar energy, energy from battery and energy from the provider to run appliances of a subscriber. We think about the state of affairs where the subscriber will offer excess energy that is generated, back to the grid, thereby reducing the load on the grid during peak hours [3]. This paper mainly focusses on the impact of distributed generation and best feeder reconfiguration of distribution system, in order to improve the quality of power in the distribution system. Primarily the goal of this paper is to mitigate as much as possible the losses in power system and improve the voltage profile. The improved of the system affected by feeder capability limit, radial configuration format, no load point interruption and load-point voltage limits. [4].

1.1. Proposed System

It is proposed to incorporate DSM in the power system. The DSM alters the losses of the transmission line thereby controlling the real power flow in the transmission lines. The standard 30 bus system is used for analysis and the DSM is incorporated in transmission lines where costs and losses are reduced. The line data and load data are taken from the standard IEEE 33 bus system.

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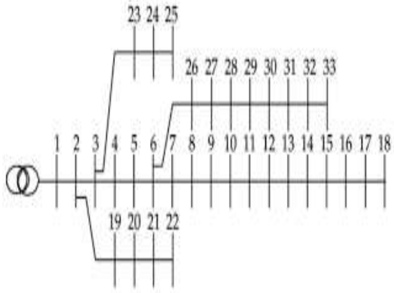

Fig -1.1: One line diagram of IEEE standard 33 bus system

2. Demand Side Management

Demand-side management (DSM) or demand-side response (DSR), is the modification of customer demand for energy through varied method .Usually, the goal of demand-side management is to encourage the consumer to use less energy during peak hours, or to move the time of energy use to off-peak times such as night time and weekends. An example is the use of energy storage units to store energy during off-peak hours and discharge them during peak hours. A newer application for DSM is to aid grid operators in balancing intermittent generation from wind and solar units, particularly when the timing and magnitude of energy demand does not coincide with the renewable generation.

Types of Demand Side Management:

2.1 Energy efficiency: Using less power to perform the same tasks. This involves a permanent reduction of demand by mistreatment additional economic load-intensive appliances.

2.2 Demand Response: Demand response includes all intentional modifications to consumption patterns of electricity of end users that are supposed to change the temporal arrangement, level of fast demand, or the total electricity consumption.

2.3. Distributed energy sources:

Distributed generation,is electrical generation and storage performed by a variety of small, grid-connected devices . Conventional power stations are centralized and require electric energy to be transferred over long distances. By contrast, DER systems are localized, standard and flexible technologies that are located close to the load they serve, albeit having capacities of only 10 megawatts (MW) or less. Sometimes, they are referred to as hybrid power systems. All these types of demand side management are incorporated in the system and the system performance is analyzed.

3. Software Used:

3.1 DIgSILENT PowerFactory Simulator

PowerFactory is a leading power system analysis software application for use in analyzing generation, transmission, distribution and industrial systems. It covers the full range of functionality from standard features to highly sophisticated and advanced applications including wind power, distributed generation, real-time simulation and performance monitoring for system testing and supervision. PowerFactory is simple, totally Windows compatible and combines reliable and versatile system modeling capabilities with progressive algorithms and a novel info thought.

3.2 DIgSILENT PowerFactory Functionality

- Ease of dynamic modeling; not reliant on default models
- Proven accuracy of results
- Lots of world-wide studies in the area of wind – many examples
- Powerful instrumentation including FFT for frequency domain representation
- Much R & D in renewable conducted in Europe commonly uses PowerFactory software
- Very strong support locally

3.3 MODES OF OPERATION

The PowerFactory Base Package provides analysis modules coupled with a wide range of power equipment models, integrated tools and features for fundamental PowerFactory applications. It includes two types of operations

- Basic Functions and Integrated Features.
- Advanced features.

3.3.1 Basic Functions and Integrated Features.

The tasks performed are

- Load Flow Analysis
- Short-Circuit Analysis
- Load Flow Sensitivities
- Basic MV/LV Network Analysis
- Network Representation
- Network Model Management
- Network Diagrams and Graphic Features
- Results and Reporting

3.3.2 Advanced Features

The tasks performed are

- Contingency Analysis
- Protection Functions
- Arc-Flash Analysis

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- Cable Analysis
- Power Quality and Harmonic Analysis
- Transmission Network Tools
- Distribution Network Tools
- Probabilistic Analysis
- Reliability Analysis Functions

4. DESIGN AND SIMULATION

The methodology implemented here is usage of alternate energy resources such as Distribution Generators and Battery and valley filing .

4.1 Alternate Energy Sources

In this paper, four cases were considered for alternate energy sources. They are

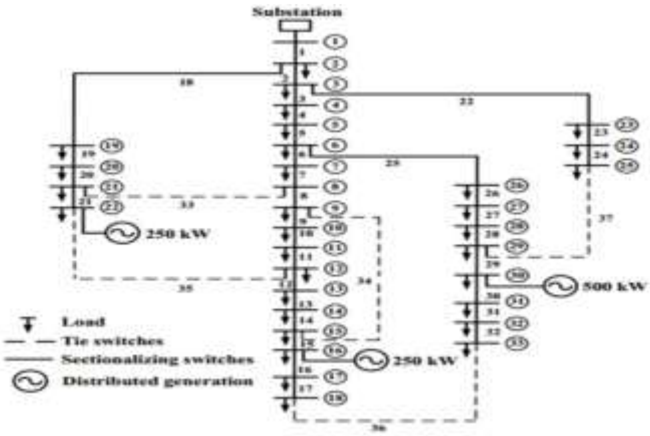

Fig 4.1: One-line diagram of IEEE standard 33 bus system with distributed generators.

4.2.1 Simulation of alternate energy sources

Case 1: IEEE 33 bus system.

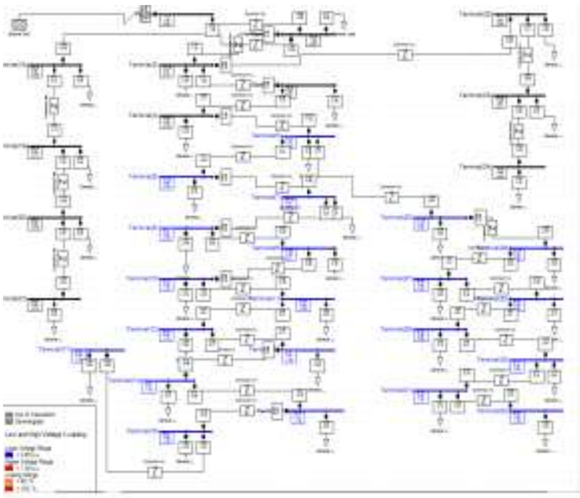

Fig 4.2 Simulation of IEEE standard 33 bus system

Case 2: IEEE 33 bus system with generator.

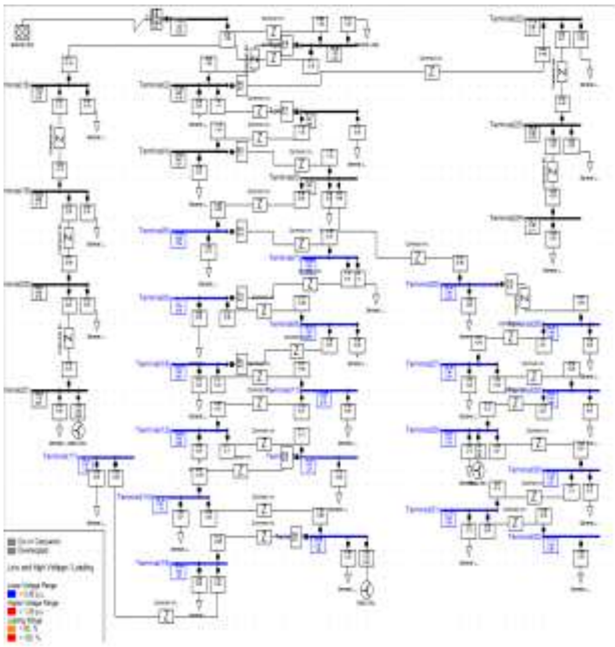

Fig 4.3 Simulation of IEEE standard 33 bus system with distributed generator

The values of the distributed generator added in the system are 250kW, 250kW and 500kW.

Case3: IEEE 33 bus system with battery

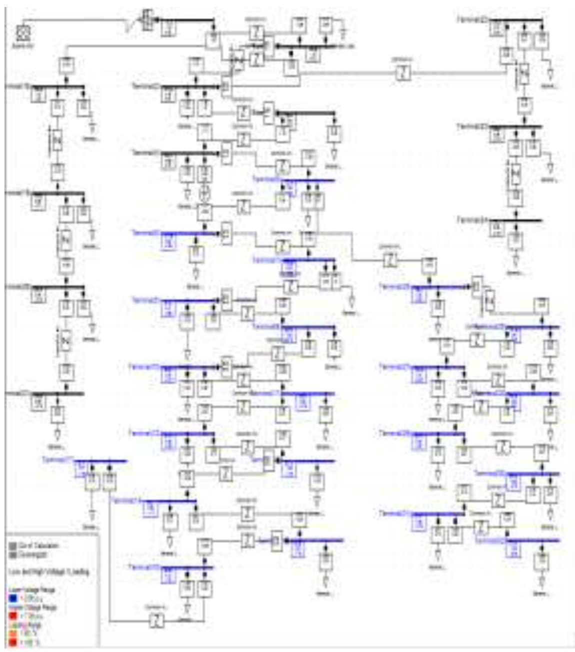

Fig 4.4 Simulation of IEEE 33 bus system with battery

The value of the battery added in the system is 500KW Li-Ion battery.

Case 4 : IEEE 33 bus system with generator and battery.

Fig 4.4 Simulation of IEEE 33 bus system with battery.

Both the battery and the generator is connected in the system.

The voltage profile and power loss both active and reactive power is compared and analysed for the effective result . Among those cases , the DSM incorprated system in which both distribution generator and battery is the effective one.

Table 1 : Comparison of losses for different cases

S.No	Cases	Active power (KW)	Reactive power (KVAr)
1	IEEE case	290	190
2	With generator	260	170
3	With battery	190	90
4	With battery and generator	150	70

Table -1: Voltage comparison of alternate energy sources.

1	X AXIS	WITHOUT GENERATOR	WITH BATTERY	WITH GENERATOR	WITH GENERATOR & BATTERY
2	1	1	1	1	1
3	2	0.995	0.996	0.997	0.997
4	3	0.974	0.977	0.981	0.982
5	4	0.962	0.967	0.974	0.976
6	5	0.951	0.958	0.967	0.97
7	6	0.924	0.932	0.95	0.952
8	7	0.918	0.926	0.946	0.946
9	8	0.91	0.918	0.942	0.941
10	9	0.9	0.907	0.938	0.933
11	10	0.89	0.898	0.934	0.927
12	11	0.888	0.896	0.934	0.926
13	12	0.886	0.894	0.933	0.925
14	13	0.876	0.884	0.931	0.919
15	14	0.872	0.88	0.931	0.917
16	15	0.869	0.877	0.932	0.916
17	16	0.867	0.875	0.934	0.916
18	17	0.864	0.872	0.93	0.913
19	18	0.863	0.871	0.929	0.912
20	19	0.995	0.995	0.996	0.997
21	20	0.989	0.989	0.994	0.995
22	21	0.988	0.988	0.994	0.994
23	22	0.987	0.987	0.995	0.995
24	23	0.968	0.971	0.975	0.976
25	24	0.957	0.96	0.964	0.966
26	25	0.951	0.955	0.959	0.96
27	26	0.922	0.929	0.949	0.95
28	27	0.918	0.926	0.947	0.948
29	28	0.904	0.912	0.94	0.941
30	29	0.895	0.913	0.935	0.936
31	30	0.89	0.899	0.933	0.934
32	31	0.883	0.891	0.927	0.928
33	32	0.882	0.89	0.925	0.926
34	33	0.881	0.889	0.925	0.926

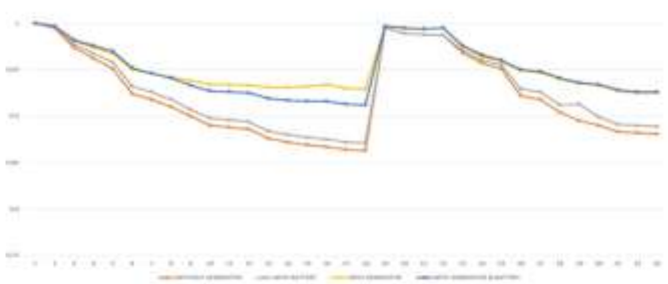

Chart1: Voltage comparison of alternate energy sources.

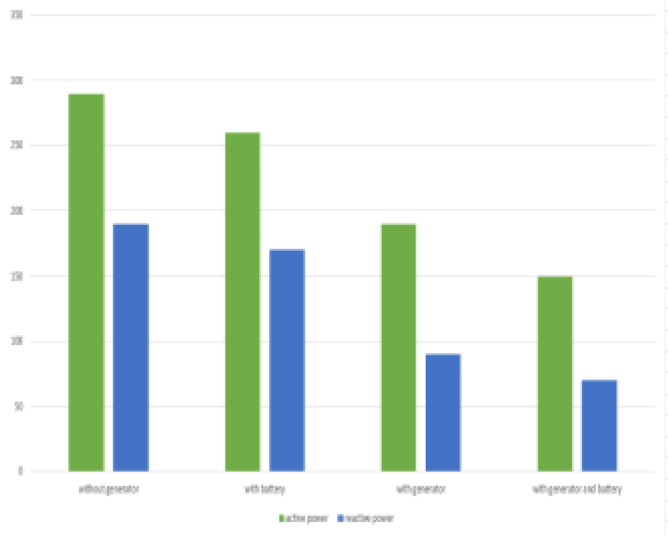

Chart 2: Comparison of losses of alternate energy sources.

4.2 Valley Filling

Valley filling is usually done together with the load shifting programs, often with the aim of shifting peak demand usage to low demand time, but the term can refer to any program aimed at filling the valley. In this paper, some of the load load are shifted from some of the buses.

Case	Bus No:	Actual Load P kW	Actual Load Q kVAr	Reduced Load P kW	Reduced Load Q kVAr	Bus No:	Actual Load P kW	Actual Load Q kV	Increased Load P kW	Increased Load Q kVAr
I	24	420	200	210	100	2	100	60	310	160
	25	420	200	210	100	3	90	40	300	140
II	32	210	100	105	50	2	100	60	205	110
III	24	420	200	210	100	2	100	60	310	160
	25	420	200	210	100	3	90	40	300	140
	32	210	100	105	50	2	100	60	205	110

Table 3 : Comparison of losses for different cases

Before Shifting P(KW)	Before Shifting Q(KVAr)	After Shifting P(KW)	After Shifting Q(KVAr)
290	90	260	180
290	90	260	170
290	90	250	160

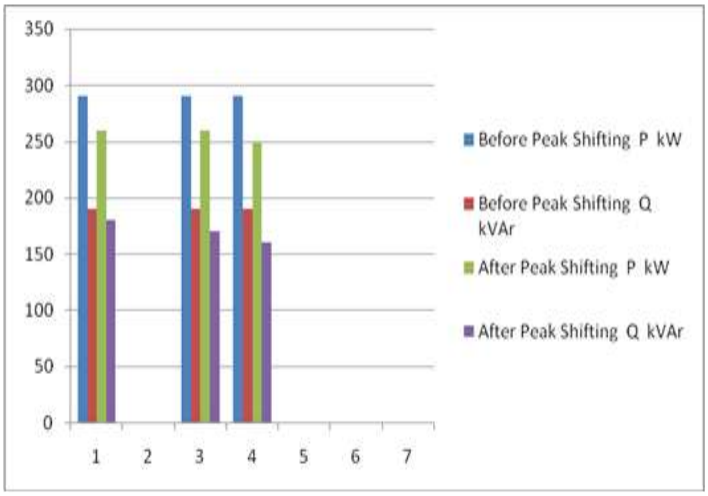

Chart 3: Comparison of losses of alternate energy sources.

5. Conclusion

The impacts of the Demand Side Management on distribution system were studied using a simulation approach. The distribution system was modeled in DIgSILENT software environment, and the evaluation of DSM was carried out in IEEE 33 bus system. The various DSM techniques such as alternate energy sources, load shifting and valley filling for different cases is analyzed in proposed system and results were compared. Among these, Alternate Energy source method is most preferred among all the techniques. It also contributes to improve the voltage profile and stability of the system. Based on the results of this proposed work, the performance of the distribution system improves if a DSM with alternate energy sources is applied to the loads.

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