Distribution System Operation and Performance Enhancement, Applying Distribution Generation DG.s Penetration Based On Optimal Power Flow Analysis

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Abstract

Applying of distributed generations (DG) is a new approach and challenge for enhancement of a traditional electric power system operation by power injections from DGs that changes network power flows, modifying energy losses and voltage profile of the system. Proper locations of DGs in power systems are important to obtain the maximum potential benefits. Also applying optimal power flow (OPF) procedure for system analysis gives the best solution with DG penetration that helps to estimate the size and best locations for DG's.

This paper shows a real study using a real part of the Libyan Grid represented by a rural distribution of 30 KV system , that consists a group of substations, and feeder circuits considering, the maximum load connected to buses.

In this research a study will performed for enhancing power system operation performance; using OPF based on Newton- Raphson extended method, and applied NEPLAN power analysis software.

DG's will be introduced as a plain DG types that produces active and reactive powers for supporting and enhancing system performance, by choosing the best location and sizes possible according to the network configuration and loading information.

Key Words : DGs, Optimal power flow(OPF), Distribution Systems,

I- INTRODACTION

Distributed generation (DG) is considers to be any modular generation located at or near the load center. [1] **It** can applied regionally in the form of renewable sources, Such as, mini-hydro, solar, wind, and photovoltaic systems (though each of these are restricted by geographic requirements) or in the form of fuel based systems, such as fuel cells and micro turbines.

By integrating DG into the utilities power grid, line upgrades can be postponed, and there exists the possibility of greater efficiency of power delivery. Power flows could be reduced and thus losses will be minimized, in particular, heavily loaded feeders or transmission corridors can be

relive. It may also be an opportunity to improve steady state voltage quality will allowing customers and utility equipment continue more years of usage. [2,

A. TRADITIONAL CONCEPT OF POWER SYSTEMS

The traditional concept of power system in which, Electricity Generation is produced in large power plants, usually located close to the primary energy source and faraway from the consumer centers, figure (1) shows the power flow in traditional power system. The power flows only in one direction from upper voltage levels down-to customers.

Situated along the radial feeders. [4, 5]

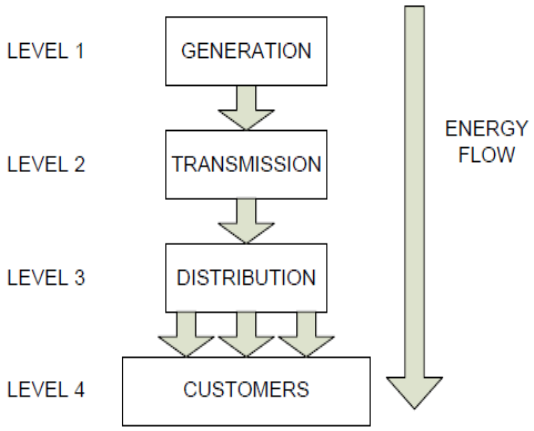

Fig (1) Traditional industrial conception of the electrical energy supply

B. NEW CONCEPT OF POWER SYSTEMS

New technologies allow the electricity to be generate in a small sized plants. Moreover, the increasing use of renewable sources in order to reduce the environmental impact of power generation, leads to the development and application of new electrical energy supply schemes. [4, 5]. As shown in figure (2).

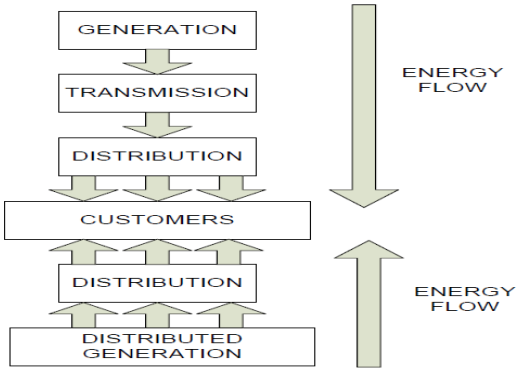

Fig (2) New industrial conception of the electrical energy suppl

II- RESEARCH METHODOLOGY AND STANDARD ASSUMPTIONS

The optimal power flow solution analysis will be applied for a chosen real distribution circuit in Tripoli area, based on Newton-Raphson extended method.

The NEPLAN software media will be used for simulation considering OPF and DG penetration.

The following standards assumption are considered for the electrical distribution system:

1) The system can be a part of all Libyan electric system and for an isolated grid.
2) The voltage regulation is $\pm$5% of nominal at system buses during normal operation mode and $\pm$ 10% at contingency.
3) The line maximum load ability is 100% of their current. Carrying capacities and 120% for contingency in two hours' time range duration.
4) The Distribution Generation may be installed at any system buses, at chosen power sizes according to OPF results.
5) System control and operation facilities are available any time.
6) Any other standards accepted by IEC standards.

III- DESCRIPTION OF THE CHOSEN DISTRIBUTION SYSTEM

The system chosen is consists of:

1) Voltage source.
2) Transformers 220/30 kv.
3) Transformers 30/11 kv.

4) Overhead lines & Underground cables.

5) Bus bars 30KV.

6) Bus couplers & Bus sections

7) Loads.

Figure (3) shows the system **c**onfiguration.

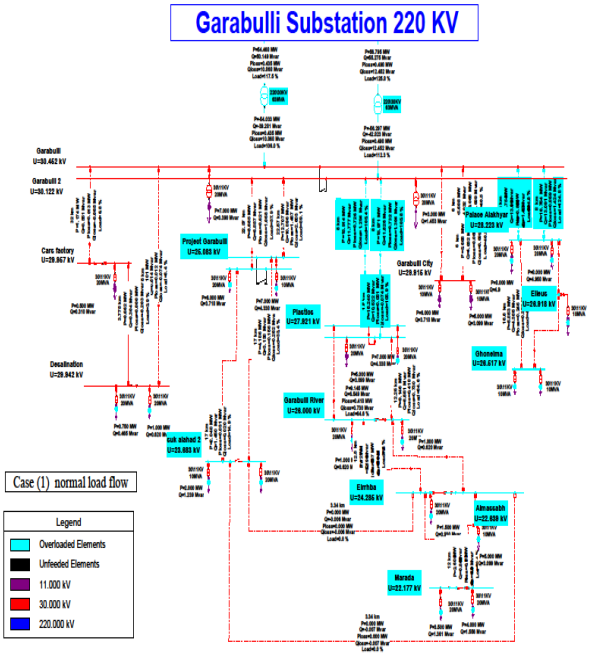

Fig (3) chosen grid system configuration

IV- RESEARCH WORKING PLANE

For the application of (OPF) to study the system performance the following steps will be considered.

1) Collect the system data and should be performed in m- files to be fed to the computer file data.

2) Set the system constrains and parameters limits.

3) Run the normal load flow program using NEPLAN software and check for system performance at peak and rated loads to identify the system weakness.

4) Check for remedy needed to the system, and cheek for performance.
5) Use the (OPF) for system analysis and check for system weakness also compare with normal power analysis.
6) Use DG penetration to the system, and study its effect on system performance considering different modes of operation.

V- CASE STUDIES AND ANALYSIS

To study the performance of an electric distribution system, the software NEPLAN is applied for optimal power flow analysis (OPF).

Also the unconventional methods of DG penetration will be applied with (OPF) to enhance the system performance, considering the DG's that produce active and reactive power.

A. SYSTEM PERFORMANCE USING OPTIMAL POWER FLOW (OPF) WITHOUT DG

In this case for the system shown in fig (3) the peak loads of the network are considered that occurs on august 2014. [6]

Appling the optimal power flow analysis table (1) shows the results.

Table (1) the optimal power flow results

Calculate	P Loss (MW)	Q Loss (MVar)	P Input (MW)	Q Input (MVar)
Optimal Power Flow	10.013	45.76	111.089	104.895

The results shows the system weakness, of voltage violation and line high load-ability, and high losses.

Figure (4) shows the voltage violation at the system bus-bars that are out of the voltage limits. Also figure (5) shows the line over-loading percentage.

Also system losses that is about 9% of the load, since the total power input was 111.089 MW and losses are 10.013 MW which is considered high.

To solve such violations by conventional replanning and redesign methods, it takes a lot of effort and high cost of construction besides the time delay of the economic growth of the society in that area, due to such construction period that takes years of time.

B- APPLYING DG PENETRATION WITH (OPF)

In this case, the DG penetration will be considered since the renewable energy has a high bright future in Libya.

The DG will be considered depending on the OPF solution that gives the size of DG unit that may installed at the lowest voltage buses, and highest line load ability. This procedure is repeated by connecting DG,s at the lowest voltage bus-bars and close to highest line loaded , and check for best performance,

Figure (6) shows the best system configuration considering DG penetration

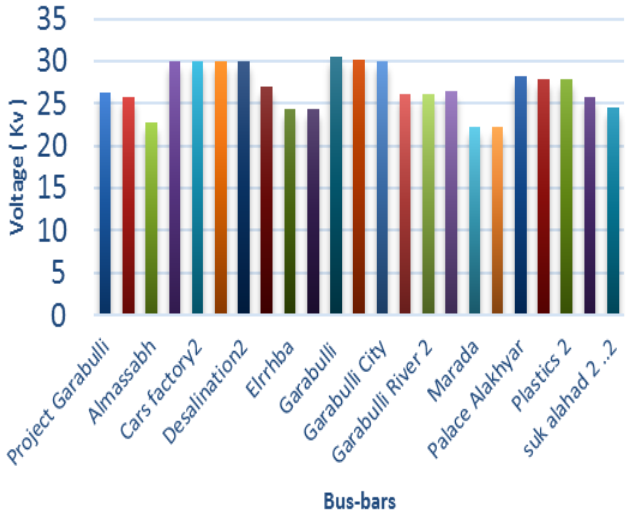

Fig (4) the bus-bar voltages profile.

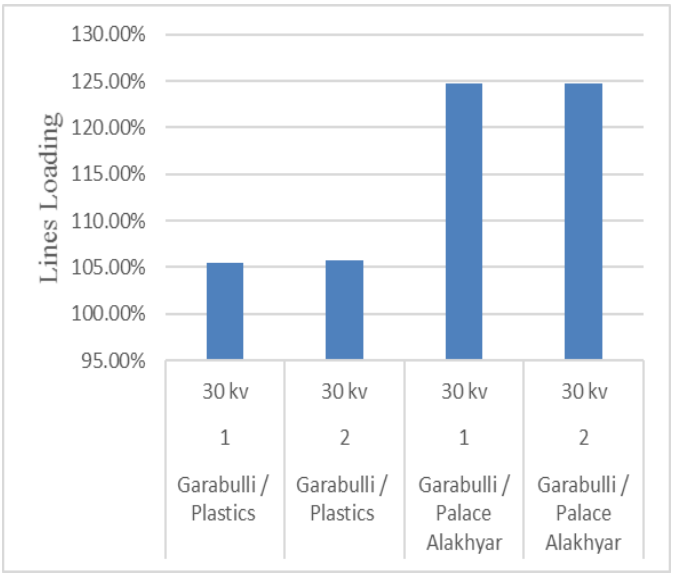

Fig (5) the lines over-loading

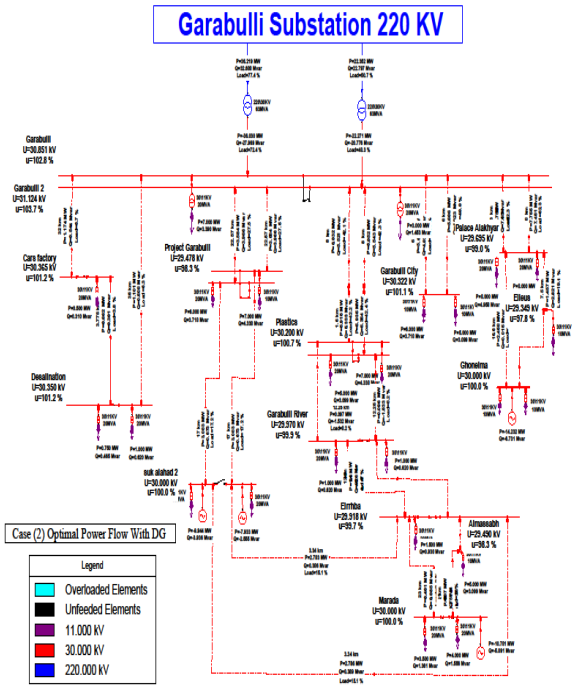

Fig (6) the best system grid configuration after DG connections

In this case, the same peak loads are considered, and the results for power losses, are shown in table (2).

Table (2) real and reactive loss with DG penetration.

Calculate	P_{Loss} (MW)	Q_{Loss} (MVar)	P_{Input} (MW)	Q_{Input} (MVar)	P_{DG} (MW)	Q_{DG} (MVar)
(OPF)	2.212	15.3684	58.572	55.484	42.89	18.308

From table (2) it seems that power loss is greatly reduced to be 2.2% and 42,3% of power is generated by DG,s

Figure (7) shows the new voltage profile. Also figure (8) shows the new line load ability.

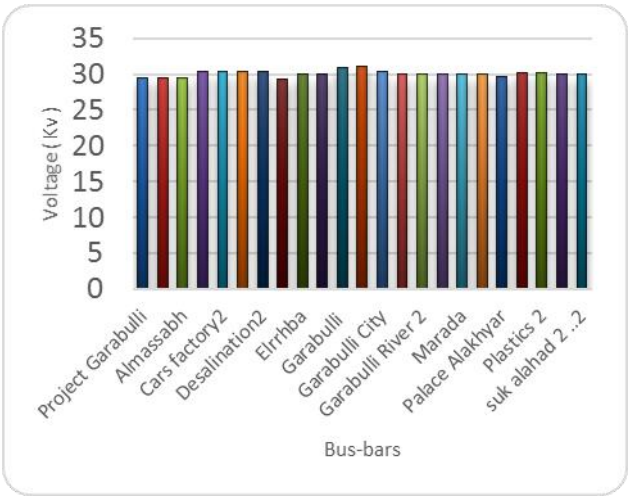

Fig (7) the bus voltages profile.

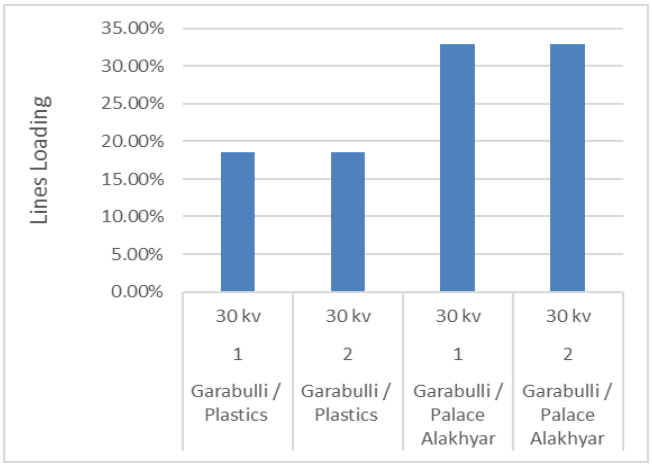

Fig (8) the lines loading reduction not exceeding 35%

A. CASE STUDY ANALYSIS

If the cost analysis are considered the reduction of system losses and good system performance will show the high reduction of cost. The 80% reduction of losses means gaining this amount as benefits. Beside savings of the cost for new substation and lines, that may used for conventional remedy.

The DG penetration shows the great benefits of using DG for distribution system that enhance the system performance of lowering the losses and reducing the line loading as well as the good voltage profile.

VI- BENEFIT OF DG'S GENERATED POWER DURING DAILY LOAD CURVE

In this case the yearly day for peak loading and yearly day for minimum loading of the system are found from the yearly system data of year 2014.

If the DG's are installed according to the case study of this research, then there will be different in power loading that may results in extra available power generation by the DG's in the system, as shown in figure (9).

As a benefit of using DG penetration, there will also be a generated power that may feeding back to the connected system network or can be stored in a way such as fuel cells, that can be used during high peaks or charging the system in case of blackout restorations.

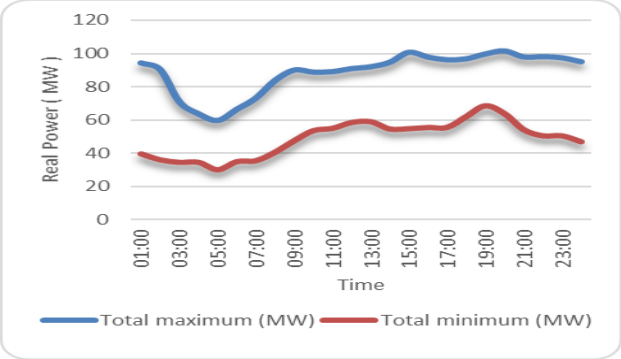

Fig (9) the daily maximum and minimum loads curve for year 2014.

Also table (3) shows the (OPF) analysis of the network for maximum and minimum daily loading, that shows a high power difference between peak and minimum daily loading that may be ejected back to the grid.

Table (3) the OPF solution results.

Maximum Load	MW	Mvar	Percentage (MW)
Power Generation From Grid	58.572	55.484	57.73%
Power Generation From DG	42.89	18.308	42.27%
Total Power Generation	101.462	73.792	100.00%
Minimum Load	**MW**	**Mvar**	**Percentage (MW)**
Power Generation From Grid	21.287	27.962	70.75%
Power Generation From DG	8.797	-7.011	29.25%
Total Power Generation	30.084	20.951	100.00%
Difference in Power	71.378	52.841	71.00%

VII- CONCLUSION

This research paper presents the analysis, the effects, and benefits of DG penetration on distribution system operation and performance, based on optimal power flow solution analysis.

The NEPLAN software is used for (OPF) analysis based on Newton – Raphson extended method.

A local distribution network is considered as a case study for analysis.

The studies shows that the DG penetration is the good solution for enhancing system performance where the following benefits are accomplished:

- Increasing system efficiency.
- Reducing system losses.
- Enhancing voltage profile and line load ability.

- Reducing the replanning costs and better handing to future load growth.
- Storage extra energy for extra loading or during power outages.
- Possibility of using renewable energy that reduce the cost.
- The total costs are greatly reduced.

VIII- REFERENCES

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