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IMPACT OF DISTRIBUTED GENERATION (DG) ON Alzahra, Libya, 30KV ELECTRIC DISTRIBUTED NETWORK

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Abstract

Libyan electric distribution networks are suffering many problems of voltage limits violation, high system losses and low system performance.

In this paper, a load flow study will be performed for a large power distribution of Alzahra area in Libya that include Alzahra power station. Considering distribution generation (DG) penetration method instead of conventional replanning methods, such as the expanding and adding methods that needs efforts and time.

Alzahra 30KV electric system is taken as the case study including Alzahra power plant, different operation cases are considered includes the operation of the considering DG penetration during peak loads.

The availability of high-performance software's such as NIPLAN helps in redesigning and replanning of electric power system for enhancing performance and solving system problems.

The loss in the general phase was 8MW, and after increasing the loads by 8%, the loss ratio increased to 10MW. When adding the distribution generation in the right place, we note that the loss has been saved to approximately 4.5MW.

KEYWORDS*:* DG, Penetration, Load flow, NIPLAN software, Voltage drop, Power system planning.

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تأثير مولدات التوزيع (DG) على شبكة التوزيع الكهربائية الزهراء –ليبيا 30 كيلو فولت

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الملخص:

تعاني شبكات توزيع الكهرباء الليبية من العديد من المشاكل المتمثلة في انتهاك حدود الجهد وارتفاع خسائر النظام وانخفاض أداء النظام.

في هذا البحث سيتم إجراء دراسة تدفق الأحمال لتوزيع الطاقة الكبيرة لمنطقة الزهراء في ليبيا والتي تشمل محطة كهرباء الزهراء. مع الأخذ في الاعتبار طريقة اختراق توليد التوزيع (DG) بدلاً من طرق إعادة التخطيط التقليدية، مثل طرق التوسيع والإضافة التي تحتاج إلى جهود. والوقت.

تم أخذ نظام الزهراء الكهربائية 30 كيلو فولت كدراسة حالة بما في ذلك محطة توليد الزهراء، وتم أخذ حالات التشغيل المختلفة في الاعتبار بما في ذلك تشغيل اختراق التيار المباشر أثناء الأحمال القصوى.

يساعد توفر البرامج عالية الأداء مثل (NIPLAN) في إعادة تصميم وإعادة تخطيط نظام الطاقة الكهربائية لتحسين الأداء وحل مشكلات أنظمة القدرة الكهربية.

وقد كانت المفاقيد في المرحلة العامة 8 ميجاوات تقريبا، وبعد زيادة الأحمال بنسبة 8% ارتفعت نسبة المفاقيد إلى 10 ميجاوات تقريبا. عند إضافة مولدات التوزيع في المكان المناسب، نلاحظ أنه تم توفير الخسارة إلى ما يقرب من 4.5 ميجاوات.

الكلمات المفتاحية: مولدات التوزيع، الاختراق أو التسرب، تدفق الأحمال، برنامج النيبلان، هبوط الجهد، تخطيط نظام الطاقة.

1. Introduction

The later advancement of modern vitality changes advances like micro-cogeneration, gas motors, sun powered cells and fuel cells,

yields the challenging assignment to plan financial and natural ideal vitality frameworks to incorporate them.
The plausibility to combine a few distinctive forms and vitality carriers in examinations of complex vitality frameworks requires a much bigger adaptability than classical technical-economic investigations [1].

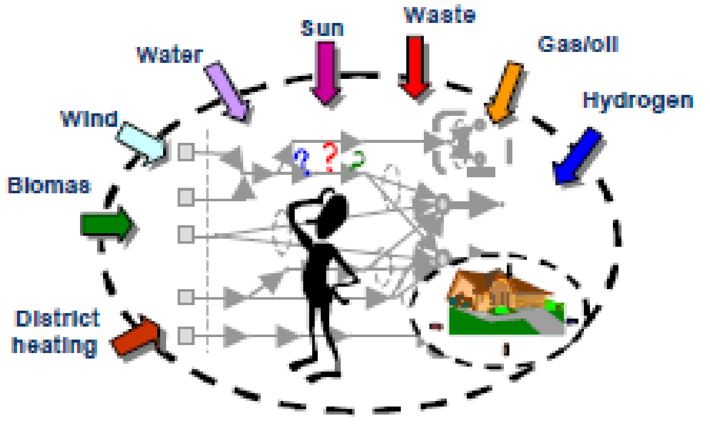

Figure 1. The recent development of new energy conversion Technologies [1]

Load-flow studies, also known as power-flow studies, are essential analyses in power system engineering. These studies are used to determine the voltage, current, power, and losses in an electrical power system under steady-state conditions. They provide critical information for the design, operation, and planning of electrical power systems.
The recent development of new energy conversion technologies like micro-cogeneration, gas engines, solar cells and fuel cells, yields the challenging task to design economic and environmental optimal energy systems to include them as illustrated in figure (1) above.
The objective of any load-flow program is to produce the following information:

- Voltage magnitude and phase angle at each bus
- Real and reactive power flowing in each element
- Knowing the voltage drop in the bus bars.

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2. Energy systems

Over time, complex socio-technical frameworks have built up around the vitality supply structure. The vitality framework has modified over time as a result of mechanical development and different social, financial and natural changes.

The term "energy systems" is regularly related with electric control. At first the generation of power was based basically on coal, but hydro, oil, common gas and atomic vitality has in this way been presented on a huge scale. Taking after the oil emergency of the 1970s, normal gas expanded its advertise share and vitality came to be for the most part utilized more proficiently, both in power era and in end-use applications[2].

3. Distribution Generation (DG)

Distributed generation (DG) refers to the production of electricity from small-scale power generation technologies located close to the point of use, rather than at large, centralized power plants. DG systems often utilize renewable energy sources, but they can also include traditional fossil-fuel-based generators as illustrated in figures (2 & 3) below [2,3].

A- TRADITIONAL CONCEPT OF POWER SYSTEMS

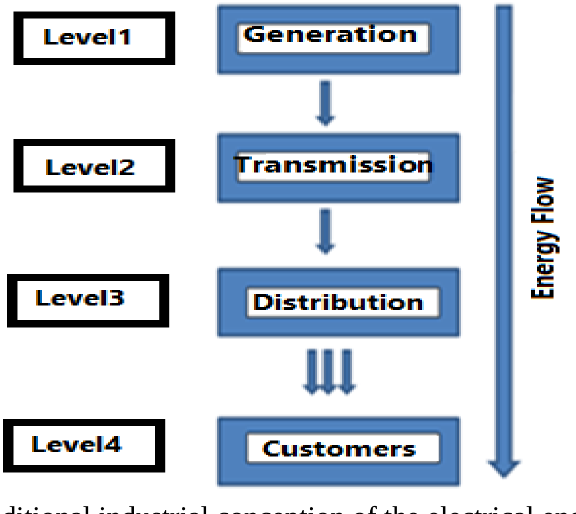

Figure 2. Traditional industrial conception of the electrical energy supply [2].

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B- NEW CONCEPT OF POWER SYSTEMS

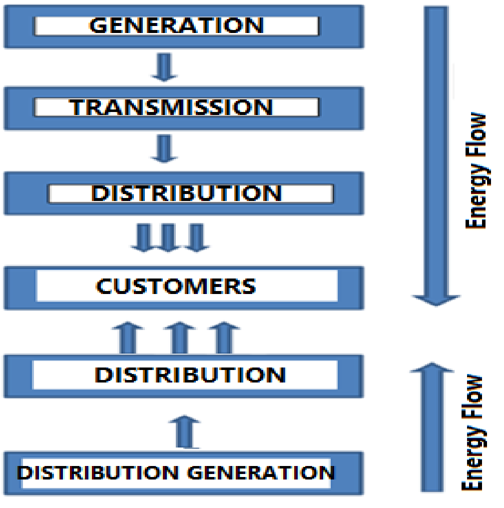

Figure 3. The conception of the electrical energy supple[2]

4. Benefits of Distribution Generation

- **Energy Efficiency:**
  - Reduces transmission and distribution losses by generating electricity close to the point of use.
  - Enhances energy efficiency through combined heat and power systems.
- **Reliability and Resilience:**
  - Increases grid reliability by diversifying power sources.
  - Provides backup power during grid outages.
- **Environmental Impact:**
  - Reduces greenhouse gas emissions when using renewable sources.
  - Lowers air pollution compared to traditional power plants [4].
- **Economic Benefits:**
  - Decreases electricity costs for consumers over time.
  - Promotes local job creation in installation and maintenance of DG systems.

5. Problem Formulation

Most of Libyan electric network parts has not been studied and analyzed for load flow. Basically, AL Zahra power plant is feeding a 30KV system network which connected to the Libyan electric network need to be studied and analyzed for load flow at different operating modes.

6. RESEARCH WORKING PLAN

The application of load flow (LF) can be used to study the system performance, and 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.

7. Description of the chosen Distribution system

The electric power system used for the study is illustrated in figure (4). The components of the electric power system are illustrated as follows:

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.

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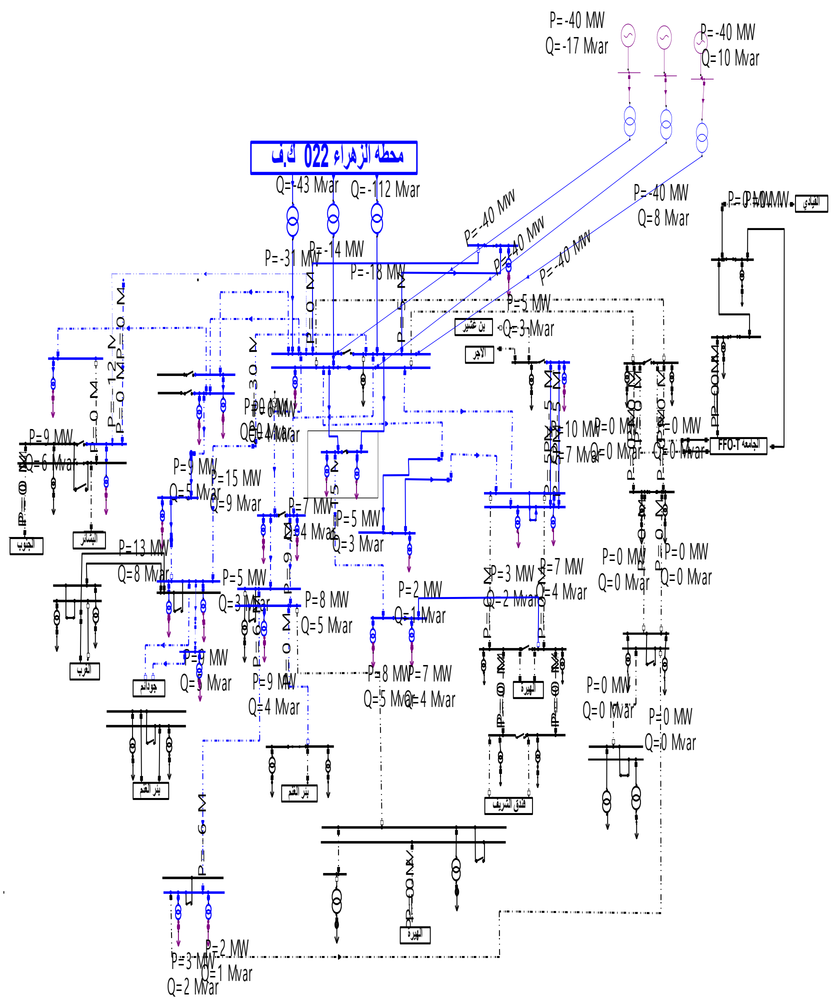

Figure 4. The configuration line diagram Alzahra 30KV [5, 6]

8. Case Studies and analysis

In the general phase, it is noticed that the loop suffers from a voltage drop in some of the buses connected to the electric power system as shown in table (1) below.

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Table1. The results for system analysis

Iteration data									
Iterations:	14								
Mismatch:	0.0007								
From	To	P Loss	Q Loss	P Imp	Q Imp	P Gen	Q Gen	P Load	Q Load
Area/Zone	Area/Zone	MW	MVar	MW	MVar	MW	MVar	MW	MVar
Network		7.795	39.496	38.737	141.127	158.737	131.504	150.94	91.987
Area 1		7.795	39.496	0	0	158.737	131.504	150.94	91.987
Zone 1		7.795	39.496	0	0	158.737	131.504	150.94	91.987
Un		P Loss Line	Q Loss Lir	P Loss Tra	Q Loss Transformer				
kV		MW	MVar	MW	MVar				
30		6.271	4.853	1.077	25.74				
220		0	0	0.446	8.903				
Overloads									
Nodes (lower)	%								
N1077349567	94.25								
المايا	93.34								
B-1229834707	93.27								
سوق الخضار	93.06								
2-30 مفرق السواني	91.64								
N1077349624	90.75								
السواني	90.53								
Nodes (upper)	%								
N1077349456	107.14								
N1077349687	105.29								
N1077349558	105.03								

The results for system analysis shows that the system suffering voltage violation for most bus bars and high load ability of some lines as shown in table (1), and figure (5)which illustrates the system weaknesses.

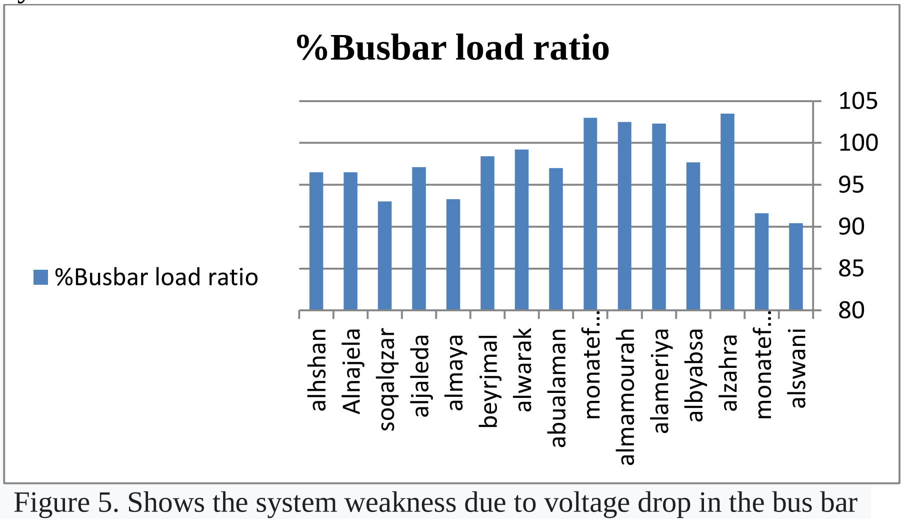

Figure 5. Shows the system weakness due to voltage drop in the bus bar

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Figure (6) below shows the second stage after increasing the loads by 8%.

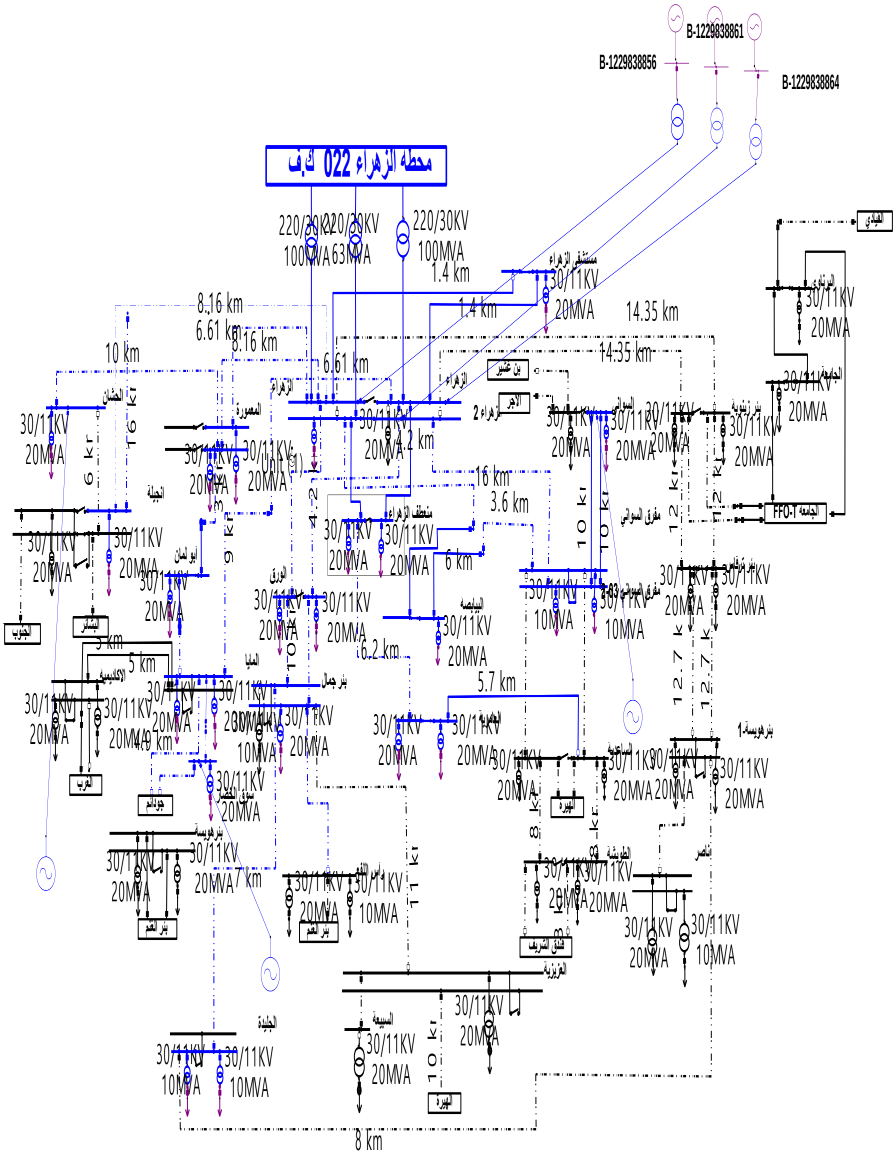

Figure 6. Increasing the loads by 8% [5, 6]

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It is noticed that when the loads are increased by 8%, there is a voltage drop in some bus bars, as well as losses in transmission lines in the second stage as well as seen in table (2) and figure (7) below.

Table.2 The normal optimal load flow for Alzahra power generators is connected.

Iteration data									
Iterations:	14								
Mismatch:	0.00074								
From	To	P Loss	Q Loss	P Imp	Q Imp	P Gen	Q Gen	P Load	Q Load
Area/Zone	Area/Zone	MW	MVar	MW	MVar	MW	MVar	MW	MVar
Network		8.874	43.713	49.198	147.334	169.198	141.416	160.32	97.675
Area 1		8.874	43.713	0	0	169.198	141.416	160.32	97.675
Zone 1		8.874	43.713	0	0	169.198	141.416	160.32	97.675
Un		P Loss Line	Q Loss Lir	P Loss Tra	Q Loss Transformer				
kV		MW	MVar	MW	MVar				
30		7.229	6.674	1.149	27.161				
220		0	0	0.495	9.878				
Overloads									
Nodes (lower)	%								
N1077349666	94.54								
N1077349666	94.53								
N1077349567	92.66								
المايا	91.93								
B-1229834707	91.86								
سوق الخضار	91.63								
مفرق السواني 2-30	91.51								
السواني	90.39								
N1077349624	88.76								
Nodes (upper)	%								
N1077349456	106.82								
Elements	%	Type							
EL15	102.59	Line							
EL68	97.67	Line							

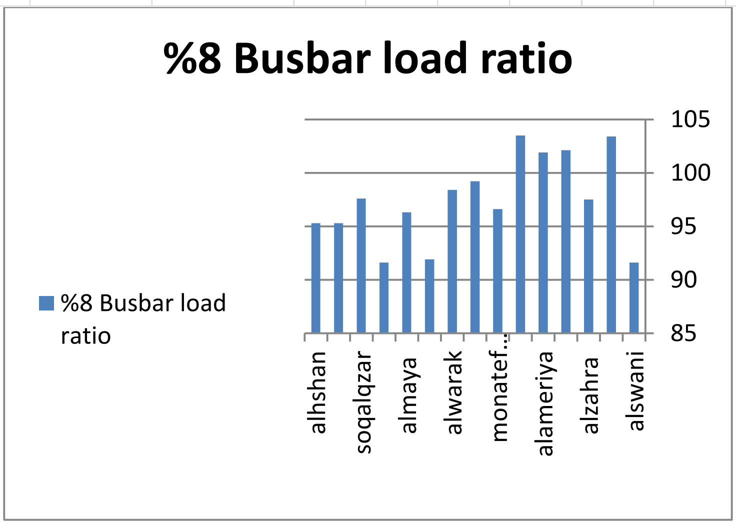

Figure 7. Showing an 8% increase in loads

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Figure (8) below illustrates the electric power system after applying DG penetration in the third stage after increasing the loads by 8%.

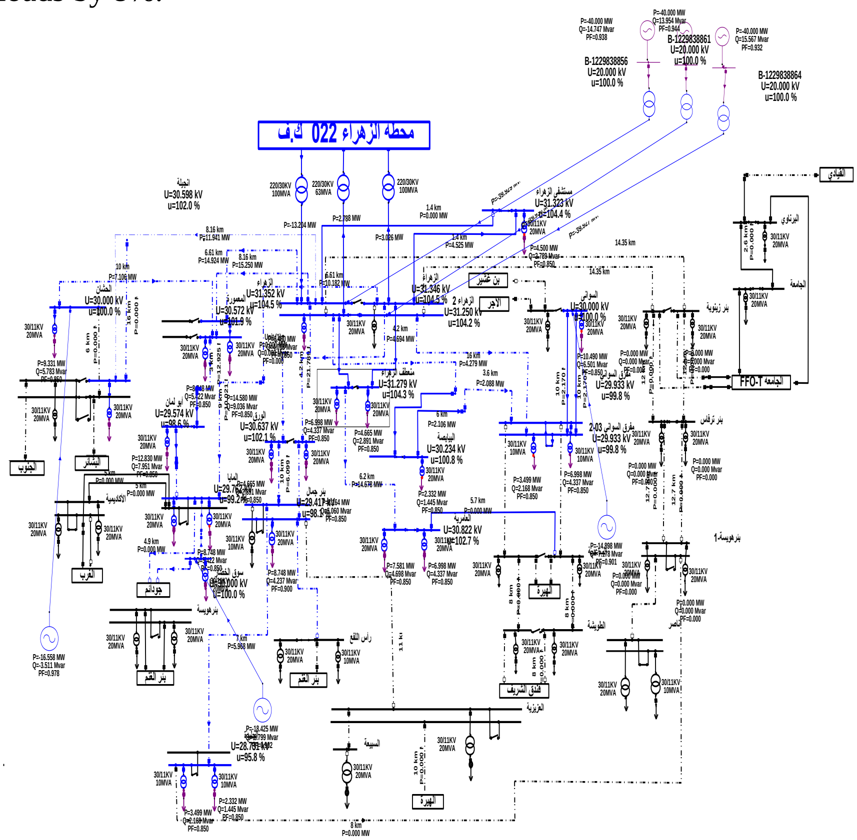

Figure 8. Applying DG Penetration[5, 6]

Table (3) below illustrated all the characteristics when the electric power system works under the normal load conditions. It shows the power losses whether it is active power, reactive power or apparent power (complex power). According to the results shown in table (3) and figure (9) below, the voltage drop is not within the limited by +5%, but after applying the DG it is reduced by about 5.5% which is allowable voltage drop limits according to standard in the electric power system operations.

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Table.3 The normal load flow for Alzahra power Plant is connected with DG.

Iteration data									
Iterations:	14								
Mismatch:	0.00078								
From	To	P Loss	Q Loss	P Imp	Q Imp	P Gen	Q Gen	P Load	Q Load
Area/Zone	Area/Zone	MW	MVar	MW	MVar	MW	MVar	MW	MVar
Network		4.563	34.968	57.656	155.205	177.656	140.431	173.091	105.456
Area 1		4.563	34.968	0	0	183.168	43.179	178.603	8.204
Zone 1		4.563	34.968	0	0	183.168	43.179	178.603	8.204
Un		P Loss Lin	Q Loss Lir	P Loss Tra	Q Loss Transformer				
kV		MW	MVar	MW	MVar				
30		2.954	-1.442	1.222	28.718				
220		0	0	0.385	7.692				
Overloads									
Nodes (upper)	%								
N1077349456	110.45								
N1077349465	106.74								
N1077349456	106.48								
N1077349621	106.27								
N1077349558	105.59								

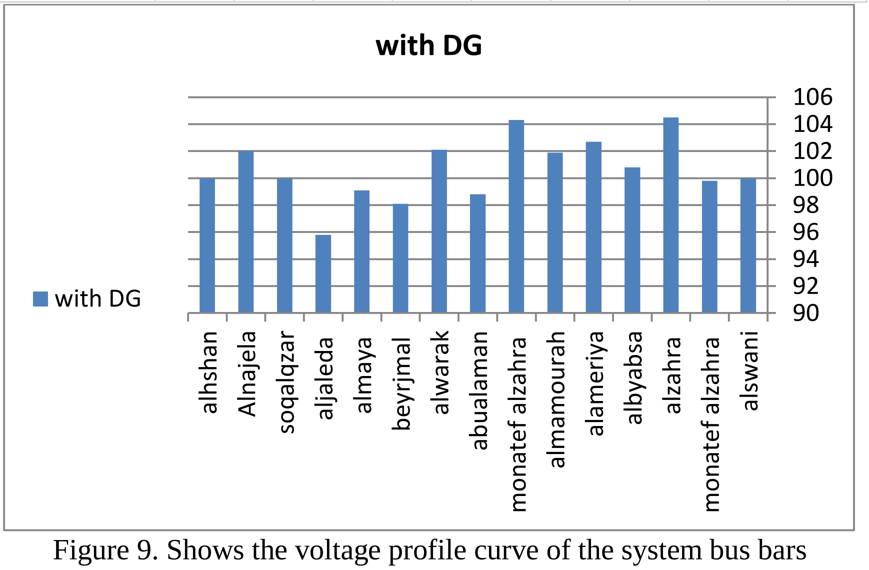

Figure 9. Shows the voltage profile curve of the system bus bars

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The relationship between the energy production in megawatts and the load ratio is shown in table (4). After using the excel program for curve fittings to analyze the computed data received from NEPLAN software, the rate curve appears as shown in figures (10 & 11) below.

Table 4. Illustrates the energy production in megawatts and the load ratio

with DG	%8 Busbar	%Busbar lo	Name
100	91.6	90.4	alswani
99.8	103.4	91.6	monatef alz
104.5	97.5	103.5	alzahra
100.8	102.1	97.7	albyabsa
102.7	101.9	102.3	alameriya
101.9	103.5	102.5	almamourah
104.3	96.6	103	monatef alz
98.8	99.2	97	abualaman
102.1	98.4	99.2	alwarak
98.1	91.9	98.4	beyrjmal
99.1	96.3	93.3	almaya
95.8	91.6	97.1	aljaleda
100	97.6	93	soqalqzar
102	95.3	96.5	Alnajela
100	95.3	96.5	alhshan

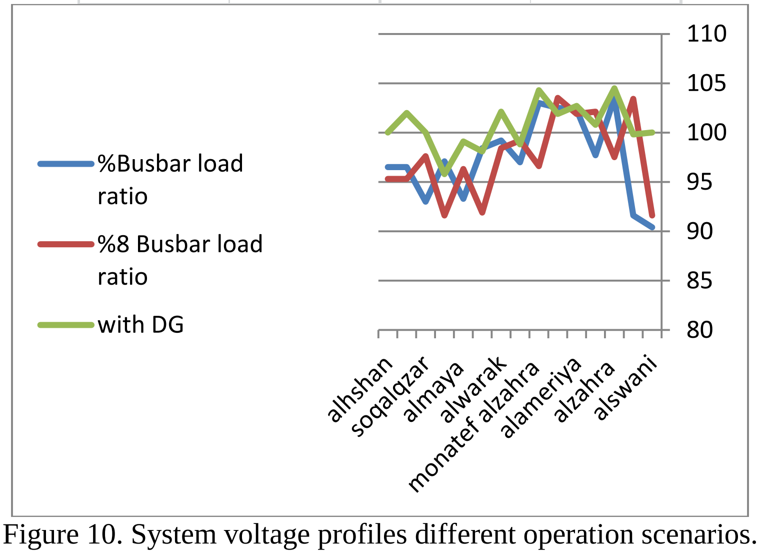

Figure 10. System voltage profiles different operation scenarios.

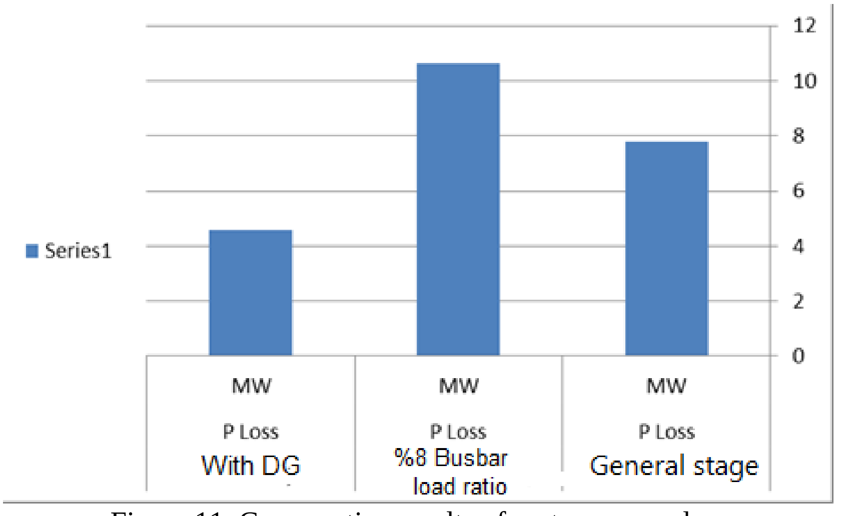

Figure 11. Comparative results of system power loss

9. Conclusion

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

The NEPLAN software is used for load flow (LF) analysis based on **Newton – Raphson** extended method .

In summary, distributed generations (**DGs**') offer a sustainable and resilient approach to energy production with numerous benefits. On the other hand, it presents more challenges that need to be well addressed through technological advancements, supportive policies, and effective grid management strategies as well. The main results illustrated in figure (11), clarify that when there are no distribution generations, both power losses in the general stage and on the busbar is significantly higher high comparing with the electric power system when it is connected through a distribution generation.

The illustrated studies in this paper show that the **DG** penetration is the good solution for enhancing system performance where the following benefits are accomplished, which can lead to the following aspects:

- Increasing system efficiency
- Reducing system losses.

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