# The Effect of Distributed Generation on Distributed Network

Mohammed O Bahabri
College of Electrical Engineering, King Abdul-Aziz University, Jeddah, Saudi Arabia

**Abstract**
The work has a practical model which is feasible and applicable in King Abdulaziz University Hospital KAUH Intensive Care Unit ICU that consists of 9-bus system. Because of solar energy generation is a part of distributed generation; the solar PV was represented as distributed generators. The research focus on applying power flow method on 9 bus network. The power flow was studied with/without added distributed generators (DGs).
**Keywords:** Distributed Generators DGs, Distributed netowrk, Power Flow, Voltage Profile, Power Losses.

## 1. Introduction

Distributed generation is an electric power supply with small scale usually from 1 kW – 50 MW which produce energy at site close to load or customers. Distributed generators are not limited to heat cycle generators as synchronous generators, induction generators; they are including fuel cells, wind turbine and generally renewable energy. [1]

A renewable resource is a natural resource that has the ability to replenish or reoccur frequently with time, through either biological reproduction or other naturally recurring processes on a human time scale. What give advantages for renewable resources over non-renewable ones are their richness, availability and sustainability .Renewable energy provided by such resources could effectively contribute to face the rapid growing demand of power all over the world. [2] The necessity for switching to renewable energy has come because of many reasons. One of the most important reasons for the renewable energy deployment is conservation of environment. Consumption of fossil fuel resources such as coal and petroleum and its derivatives produces many undesirable components that, in a way or another, could cause a catastrophic pollution to the Earth. Burning fossil fuels is the main cause of increased $CO_2$ in air. In 2010, an amount of 33.5 gigatonnes of carbon dioxide ($CO_2$) was released in the atmosphere from fossil fuels and cements production all over the world [3, 4].

In this paper, will make study to 9 bus system which is King Abdulaziz University Hospital network in Intensive Care Unit (KAUH ICU). By Power World simulator, power flow can be applied on distributed network without added distributed generators or with added distributed generators DGs. Power flow can represent voltage profile and power losses wither without/with added DGs. By analyzing the comparison between applying power flow without/with can find results and differences lead to findings?

## 2. Modeling KAUH ICU

As show in Single Line Digram in figure 1, there is high voltage substation UNI2 which is feeding health sience center of King Abdulaziz University we assumed that is only and highest capacity generator. Also, there are many loops and ring circuits so, let us focus on circuits or feeders which supply Kind Abdulaziz University Hospital exactly Intensive Care Unit KAUH ICU.

 

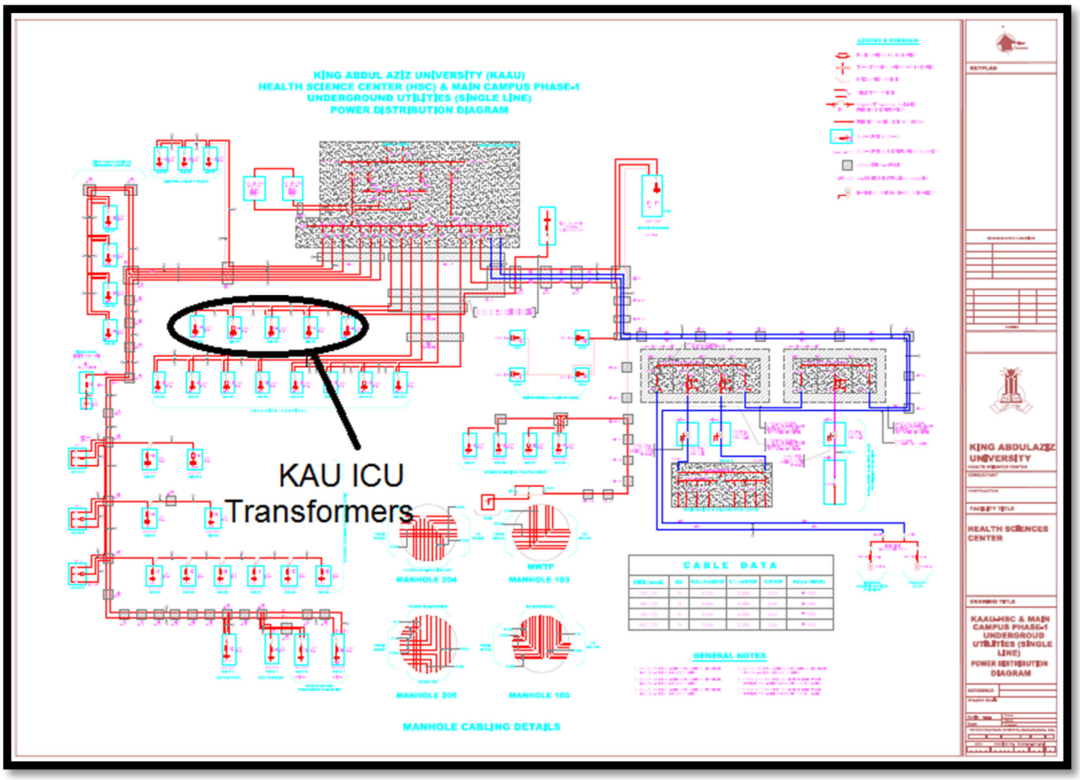


Figure 1: Single Line Digram for Health Science Center Distribution Network

The model was built as it is existing in site and single line diagram so there are 5 transformers each transformer has 1000 KVA. According to rating of each transformer we adjust each load belong to 1000 KVA.

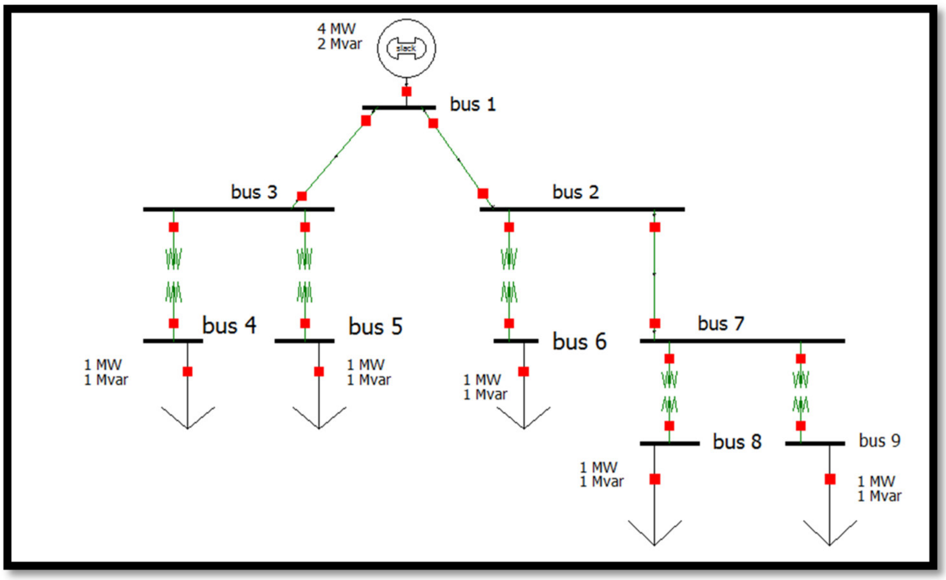


**Figure 2 : KAUH ICU model**

Before Starting run power flow there is a need to determine line data and bus data. The model is small model consist of 9 nodes or buses , one generator on slack bus, 5 load buses, 5 branch transformers and 3 lines. In the beginning, determine bus data then will find line data .

$$Vn = 1$$

$$\&n = 0$$

Where:

V$n$: Bus voltage magnitude in each bus

$\&n$: Bus voltage angle in each bus

 

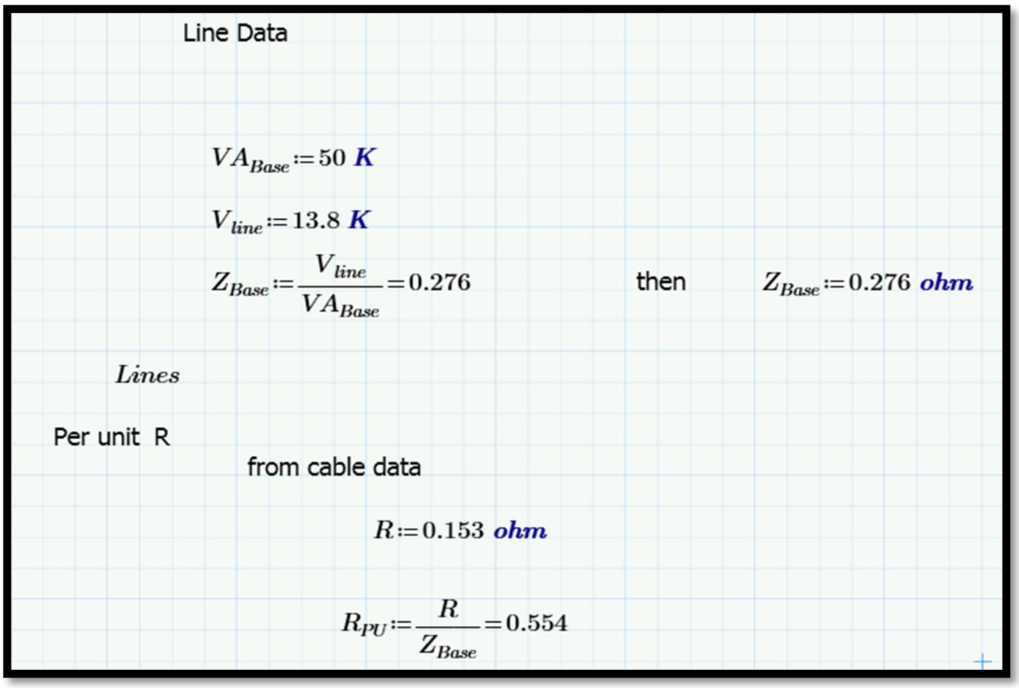


**Figure 3 : Per unit R calculation branch line**

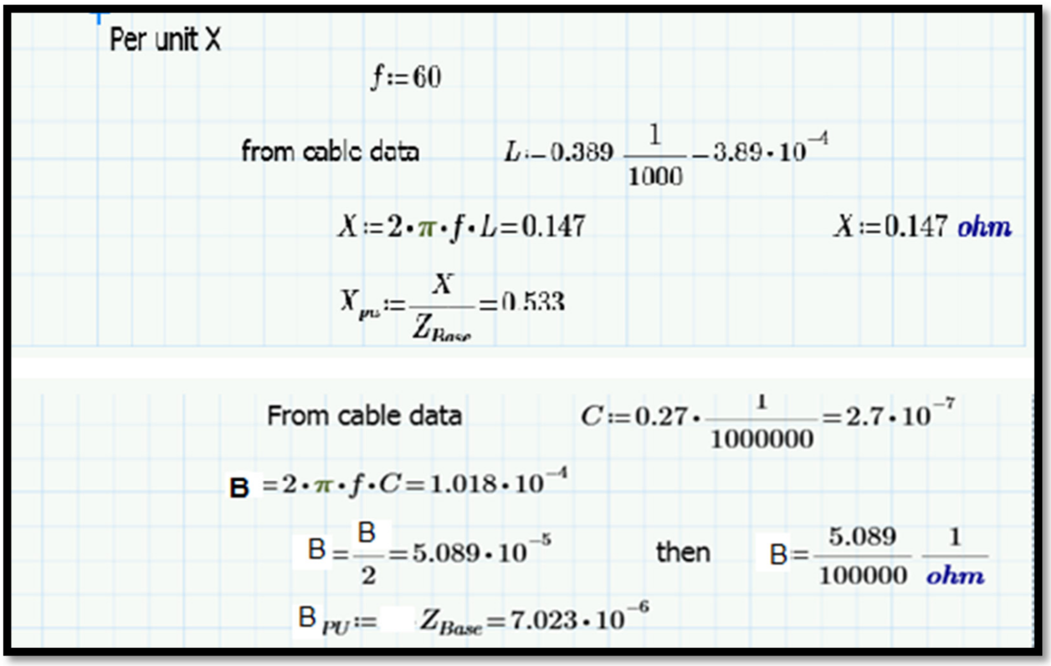


**Figure 4 : Per unit X and B calculation for branch line.**

About transformers impedance data, it is per unit three phase impedance shown in table 1. No need to calculate and determine. Table was taken from textbook [Short Circuit Calculation]

Table 1 : Percent R, X and Z based on Transformer KVA

| Transformer Rating KVA | X/R | R % | X % | Z % |
|---|---|---|---|---|
| 150 | 3.24 | 1.23 | 4.0 | 4.19 |
| 225 | 3.35 | 1.19 | 4.0 | 4.17 |
| 300 | 3.50 | 1.14 | 4.0 | 4.16 |
| 500 | 3.85 | 1.04 | 4.0 | 4.12 |
| 750 | 5.45 | 0.94 | 5.1 | 5.19 |
| 1000 | 5.70 | 0.89 | 5.1 | 5.19 |
| 1500 | 6.15 | 0.83 | 5.1 | 5.18 |
| 2000 | 6.63 | 0.77 | 5.1 | 5.17 |
| 150 | 1.5 | 1.111 | 1.665 | 2.0 |
| 225 | 1.5 | 1.111 | 1.665 | 2.0 |
| 300 | 1.5 | 1.111 | 1.665 | 2.0 |
| 500 | 1.5 | 1.111 | 1.665 | 2.0 |

## 3. ADDIED DISTRIBUTED GENERATORS TO KAUH ICU 9 BUS SYSTEM

The solar panels are analysed by modelling the available area on the rooftop of KAUH. The KAUH model improves the distribution network system. Node 1 is set as the slack bus, and nodes 4, 6 and 8 are set as DGs..

Table 2: Adding distributed generators

| BUS | TYPE | POWER RATING |
|---|---|---|
| 4 | Distributed Generator | 1000 KW |
| 6 | Distributed Generator | 300 KW |
| 8 | Distributed Generator | 300 KVA |

The Power World Simulator results of the model of the KAUH ICU 9-bus system with added DGs are shown. Adding DGs to the network changes some results. As mentioned before, DGs are at bus #4 with 1 MW, bus #6 with 0.3 MW and bus #8 with 0.3 MW, as shown in Figure 5.

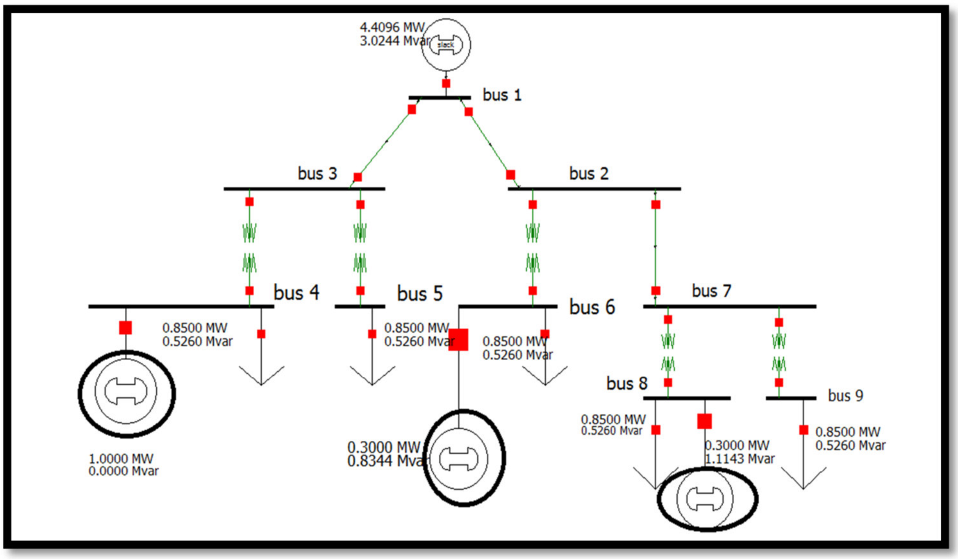


Figure 5: Distributed generators at bus #4, bus #6 and bus #8

## 4. Discussion and Conclusion

The obtained results are based on DGs used in a simulation. In actual solar generation, PVs do not provide continuous power; they only supply power for ~8 h daily. In this part, will discuss the comparison of voltage profile and power losses between KAUH ICU model without DGs and KAUH ICU with DGs so, will be started in voltage profile then power losses.

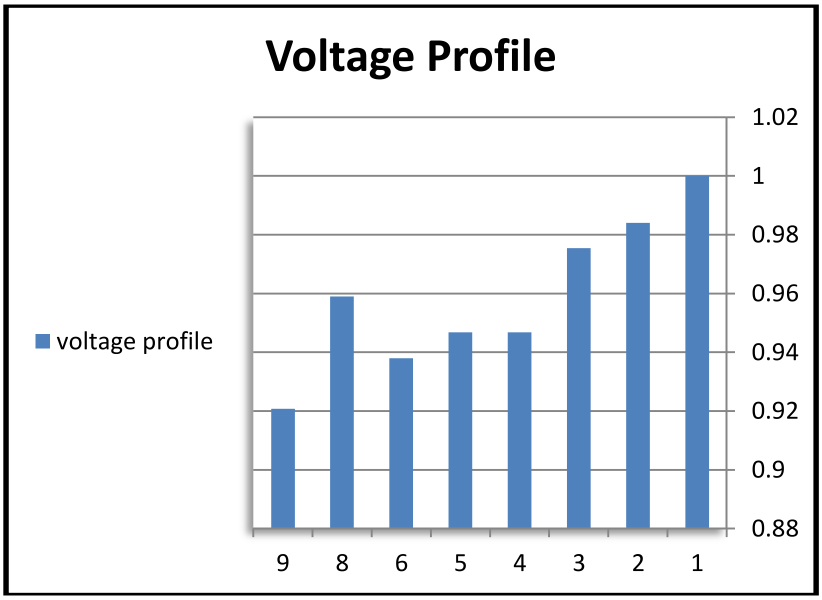


Figure 6: Buses voltage for KAUH ICU without DG

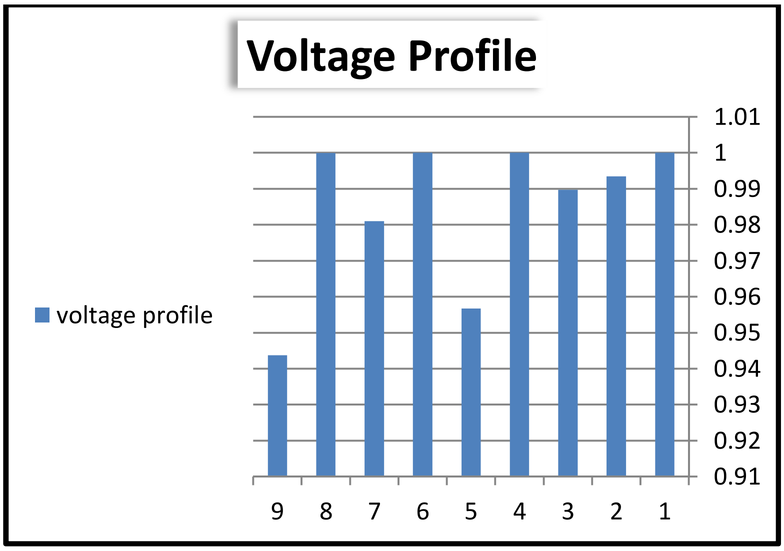


Figure 7: Buses voltage for KAUH ICU with DG

After applying power flow to 9 bus power system for KAUH ICU, there are some comments of voltage profile:

- There is an improvement at most of busses which is shown up.
- Bus # 4, bus # 6 and bus # 8 were less than 1 pu without DGs because they were Load buses.
- Bus # 4, bus # 6 and bus # 8 set equal 1 with added DGs because they become PV buses.
- No much improvement at bus # 5 and bus # 9.

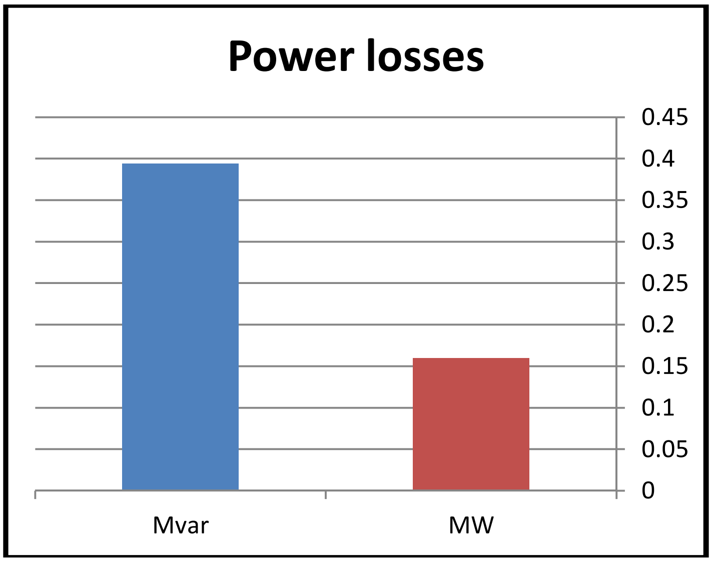


Figure 8: Power Loss of KAUH ICU without DGs

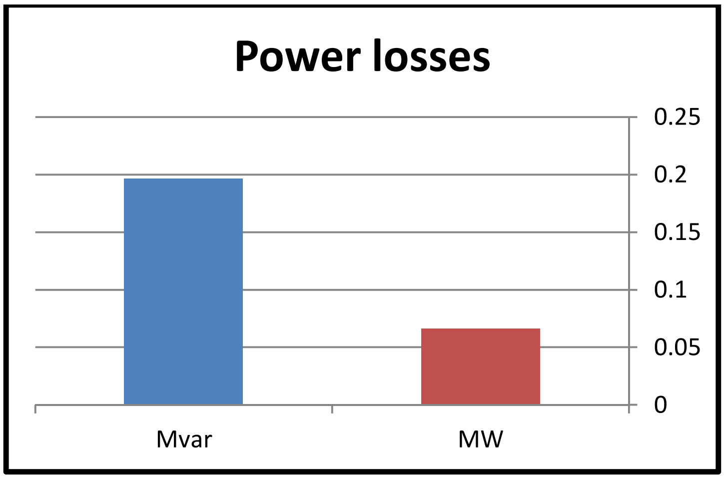


Figure 9: Power Loss of KAUH ICU with DGs

After applying power flow to 9 bus power system for KAUH ICU, there are some comments of Power losses:

- There is big difference in value of MW almost double so; distributed generators DGs reduce power losses of 9 bus system.
- Reducing power loss means reduce cost which it need cost for generating power.
- No big difference in Mvar loss with added DGs.
- Increasing number of DGs in network lead to reduce power loss.

DGs provide many benefits were approved in the paper to the distribution system operation. Some of these benefits are: energy losses could be decreased, DGs could contribute in preserving stable voltage profile along the feeders. The research has a practical model which is real and applicable in King Abdulaziz University Hospital at Intensive Care Unit KAUH ICU that consists of 9 bus system. The work focus on applying some techniques like power flow method on 9 bus network which was covered in previous pages.

**References**

[1] EPCOR, Distributed Generation basics, ResearchGate, https://www.google.com.sa/url?sa=t&rct=j&q=&esrc=s&source=web&cd=5&ved=0ahUKEwiT-.

[2] "The myth of renewable energy | Bulletin of the Atomic Scientists". Thebulletin.org. 2011-11-22. Retrieved 2013-10-03.

[3] G.P. Peters et al. Global carbon budget 2010 (summary), Tyndall Centre for Climate Change Research available online http://www.tyndall.ac.uk/global-carbon-budget-2010.

[4] Calculated from file global.1751_2008.csv from the Carbon Dioxide Information Analysis Center. Available online http://cdiac.esd.ornl.gov/.