Investigations of the effects of supplying Jenin's power distribution network by a PV generator with respect to voltage level, power losses, P.F and harmonics

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Introduction:

Due to the global trend toward the clean energy resources, it is very important to make our projects and researches related with it. Moreover, we need to find the best solutions for improving our power networks taking into consideration the best possible price which represented in the almost free sources such as solar energy, especially that we are under the occupation and we don't have control on our networks or the electricity generation.

The share of grid-connected photovoltaic (PV) power sources in power distribution systems is expected to rise due to increasing costs of traditional fossil-fuel sources and continuous reduction of PV generators worldwide. This project will present the schematic diagram of a complete PV generator with control system (design with detailed specifications) to be connected safely with the electric network in Jenin.

Problem Statement:

We will investigate what is the possibility of using PV generators in order to improve the action of the system was selected from one part of Jenin’s power distribution network that contains 25 bus in the same voltage level that consume 10.076 MW, 3.075 MVAR and total power losses 0.136 MW, 0.096 MVAR at Maximum load and consume 1.878 MW, 0.859 MVAR and total power losses 0.00538 MW, 0.00377 MVAR at Minimum load taking in consideration the voltage levels, power losses, P.F and harmonics.

Objectives:

- Find the optimal placement and sizing of distribution generation PV units in the network.
- Study the impact of the added PV DG units by conducting a new power flow study and harmonic distortion analysis.
- Economic evaluation of the added PV DG units.

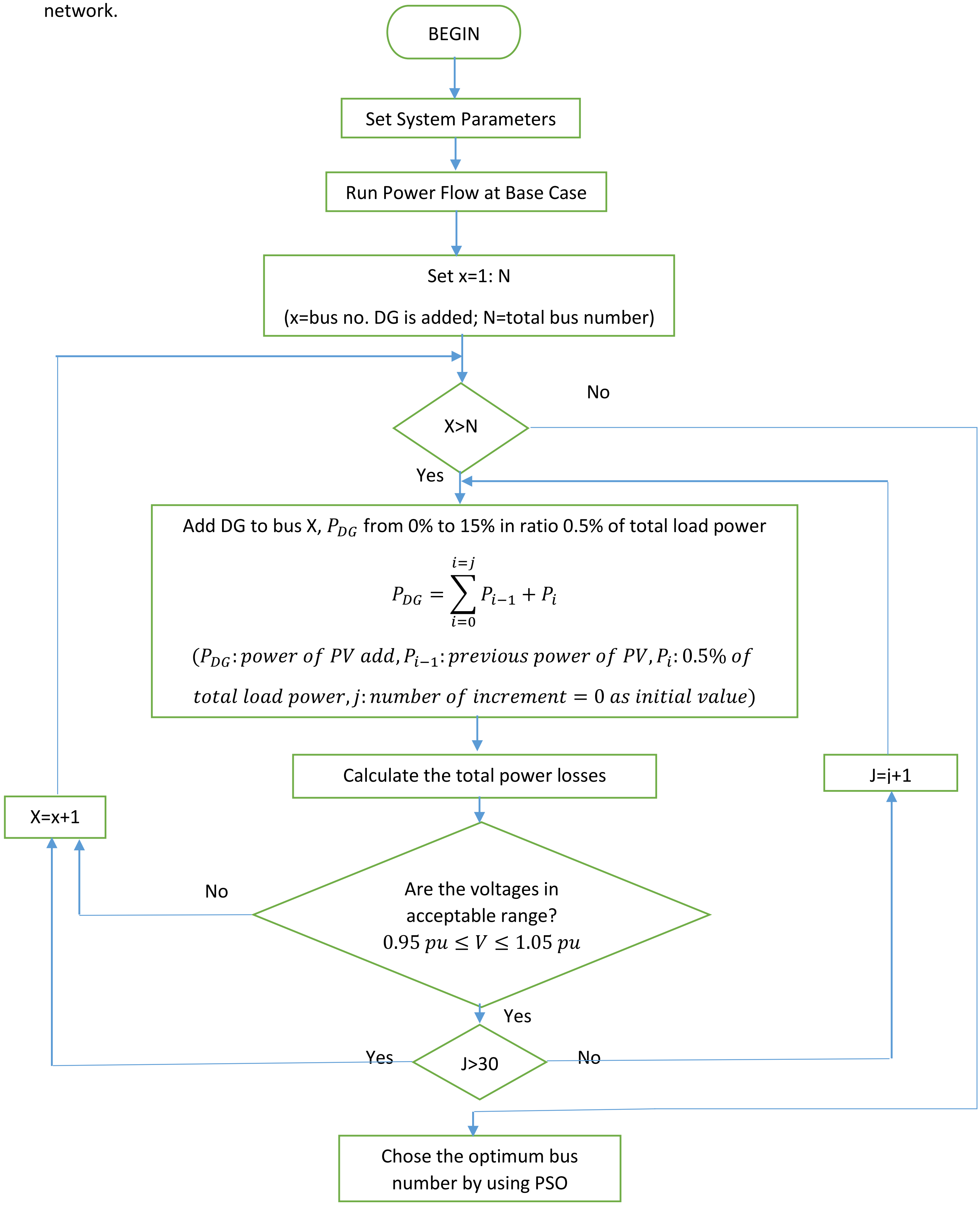
Methodology:

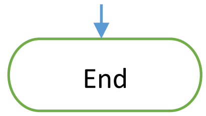
This study will be carried out on – Jenin's power distribution network-West Bank – Palestine. Some information about the network and it's component specifications (like cables, transformers, loads, ... etc) will be used. Also some specialized simulation software such as MATLAB, ETAP, and GIS are used to analyze and study the above mentioned effects.

After analyzing the targeted network, we will review relevant research work in order to layout and design an appropriate PV generator to be connected with the busses of Jenin network. After that we will use simulation models to investigate the effect s of connecting PV generator with the outlined grid. Through simulation technique, the effects of this PV on P.F, power losses, voltage level, harmonics and reactive power flow in the network will be investigated. We expect that our work will yield an improvement of power quality and distribution reliability of Jenin network by connecting of PV generators.

Part 1:

From the literature reviews we found that the more suitable methodology to have optimal location and sizing of DG in the system is one of Artificial Intelligent techniques called “Particle Swarm Optimization (PSO)” because it is fast and accurate to find the optimum location and sizing of the photovoltaic distributed generators that we can add to the system was selected from one part of Jenin's distribution network.





Part 2:

After finding the optimal location and sizing of DG that will add to the system, we will study the effects of PV DG added on the system such as; the voltage drop, total power losses, power losses between the branches, P.F, buses voltages and harmonics.

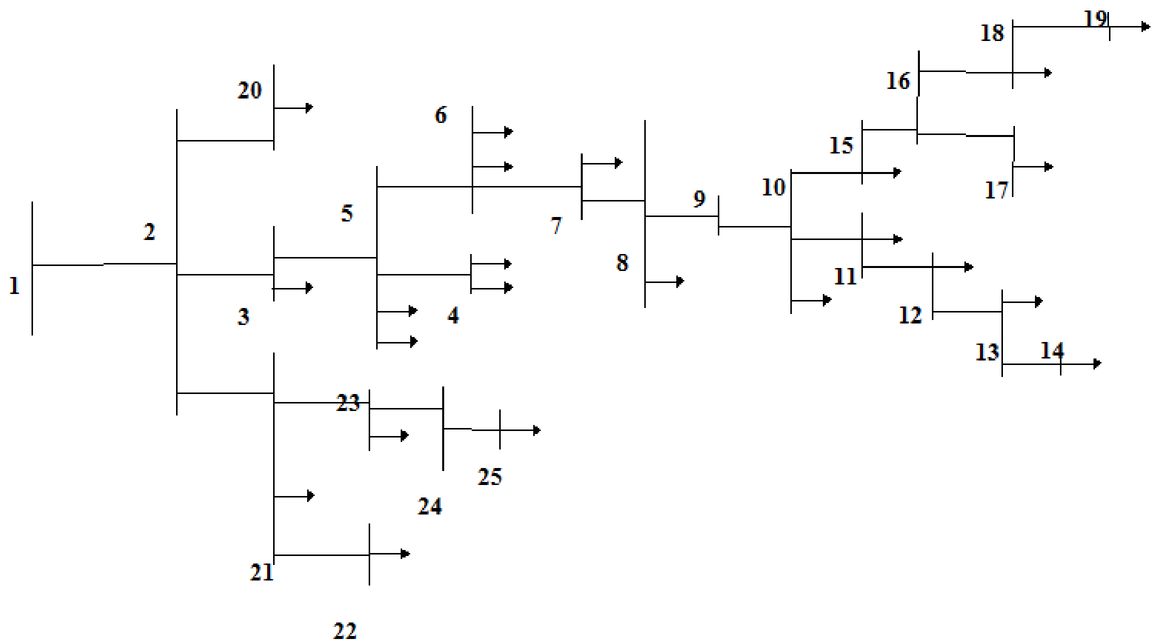
Part 3:

This part for economic evaluation of the added DG PV on the system, it will contains the capital cost of PV and the other equipment need, the saving money after reduce the total power losses and power generation, total annual saving, the saving money while 20 years (PV life cycle) and the payback period.

Results and Analysis:

Part 1:

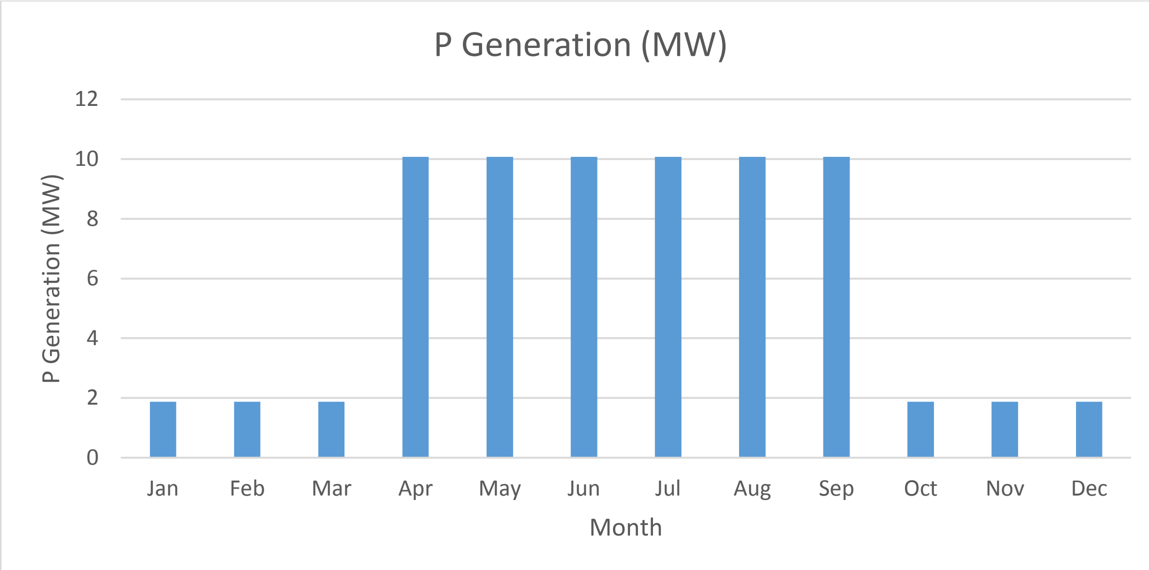
As the first results in our methodology to investigate what is the possibility of using PV generators in order to improve the action of the system was selected from one part of Jenin's power distribution network that contains 25 bus in the same voltage level taking in consideration the voltage levels, power losses, P.F and harmonics is make run of load flow in maximum and minimum loads for the system.



The system that contains 25 bus at the same Voltage levels

Load Flow by using MATLAB (Newton Raphson Method):

Month	Power Factor	Q Generation (MVAR)	P Generation (MW)	P loss (MW)	Q loss (MVAR)
Jan	0.909	0.859	1.878	0.0054	0.0038
Feb	0.909	0.859	1.878	0.0054	0.0038
Mar	0.909	0.859	1.878	0.0054	0.0038
Apr	0.96	3.075	10.076	0.136	0.096
May	0.96	3.075	10.076	0.136	0.096
Jun	0.96	3.075	10.076	0.136	0.096
Jul	0.96	3.075	10.076	0.136	0.096
Aug	0.96	3.075	10.076	0.136	0.096
Sep	0.96	3.075	10.076	0.136	0.096
Oct	0.909	0.859	1.878	0.0054	0.0038
Nov	0.909	0.859	1.878	0.0054	0.0038
Dec	0.909	0.859	1.878	0.0054	0.0038



The yearly load curve for the Main Feeder

From this yearly load curve we found that the Average Power=5.977 MW, Max. Power=10.076 MW and Load Factor= 59.32%

As we mentioned before the total DG PV added must not exceed 15% of the total load in both situation (min. and max. load) for the main feeder. We saw that the max. load for this feeder in (April., May., Jun., Jul., Aug. and Sep.) months and the min. load for this feeder in (Jan., Feb., Mar., Oct., Nov. and Dec.) months.

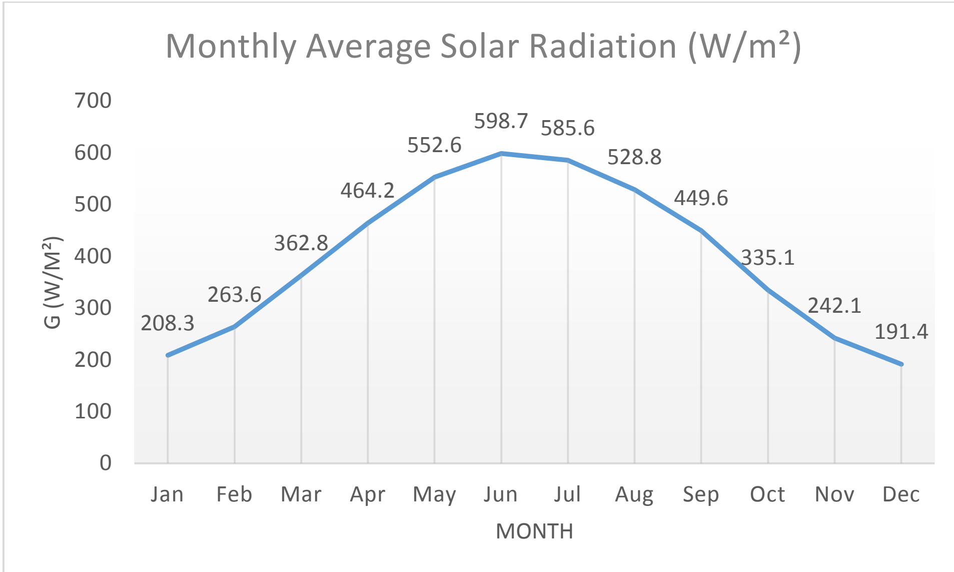
Solar Energy Parameters for Jenin:

The monthly average solar radiation that recorded by Energy Research Center in 2012 in Jenin city as the following table:

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
G(W/m^2)	208.3	263.6	362.8	464.2	552.6	598.7	585.6	528.8	449.6	335.1	242.1	191.4
T (°C)	11.3	12.7	16.7	23.1	27.9	31.3	34.0	34.2	31.5	25.7	18.7	13.2
Tilt Angle	47	45	35	29	20	15	18	25	32.5	44	55	58.5

Table 6.1 Average monthly solar radiation for Jenin City [7].

Monthly Average Solar Radiation at Jenin City:



Average monthly solar radiation for Jenin City

Peak Sun Shine Hour **5.4 H.**

The solar radiation and the temperature are changed during the year in Jenin City. So that mean the energy that generated from the PV array depends on these terms, so to have the maximum efficiency we will use tracking solar system by MPPT algorithm device to change the tilt angle 12 times per year.

The maximum demand in these months (April., May., Jun., Jul., Aug. and Sep.) is **10.076 MW** and the maximum demand in these months (Jan., Feb., Mar., Oct., Nov. and Dec.) is **1.878 MW**, so if we said that the DG PV will be 15% of the total load, we can see that the PV power needed in (April., May., Jun., Jul., Aug. and Sep.) is 1.5 MW from PV and the PV power needed in (Jan., Feb., Mar., Oct., Nov. and Dec.) is 0.2817 MW from PV.

However, we use PV module from SUNTECH com. Called (SuperPoly STP300 – 24/Vd) at STP (1000 (w/m^2), 25 (^{o}C)) to have maximum efficiency, but the average yearly solar radiation about 400 (W/m^2) so we will use 3 MW PV when we need 1.5 MW, and 800 KW PV when we need 218.7 KW by using the previous equations, we have the following that describe the power that generate from the DG PV field during the year and the suitable tilt angle needed to achieve the max. efficiency for this field :

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
G(W/m^2)	208.3	263.6	362.8	464.2	552.6	598.7	585.6	528.8	449.6	335.1	242.1	191.4
T (°C)	11.3	12.7	16.7	23.1	27.9	31.3	34.0	34.2	31.5	25.7	18.7	13.2

Tilt Angle	47	45	35	29	20	15	18	25	32.5	44	55	58.5
P generation-Max.(MW)	0.591	0.746	1.010	1.253	1.456	1.550	1.495	1.349	1.163	0.892	0.665	0.537
P generation-Min. (MW)	0.158	0.199	0.269	0.334	0.388	0.413	0.399	0.360	0.310	0.238	0.177	0.143
PV Power generation - Used (MW)	**0.158**	**0.199**	**0.269**	**1.253**	**1.456**	**1.550**	**1.495**	**1.349**	**1.163**	**0.238**	**0.177**	**0.143**

The Real Power generated yearly from the Solar Field.

After we found the optimum sizing that will add to Ayash Feeder we will find the optimum location for this DG PV field by using PSO algorithm. Firstly, we implement this size in the all buses in the feeder.

The PSO algorithm takes for each bus 6 values as an initial values for voltage profile, power factor, total real power losses and total reactive power losses by using the following equations:

$$V^{k+1} = \omega * V^k + C_1 * r2 * \left(P_{best} - S^k\right) + C_2 * r1 * \left(G_{best} - S^k\right)$$

$$S^{k+1} = V^{k+1} + S^k$$

Where:

- ω is the weighting function is usually used as follows:

$$\omega = \omega_{max} - \frac{\omega_{max} - \omega_{min}}{Itre_{max}} Itre$$

ω_{max} *and* ω_{min} : Are the maximum and minimum weights, respectively.

Appropriate values for ω_{max} *and* ω_{min} are 0.4 and 0.9 [3].

The weights for each factor as the following:

Voltage profile: 50%

Power factor: 30%

Total real power losses: 10%

Total reactive power losses: 10%

The results as the following for maximum and minimum loads as the following:

Maximum load case:

# Bus	Voltages	P.F	Total P loss	Total Q loss
12	25	3	0.09417	0.066817
16	20	2	0.094383	0.066646
18	20	2	0.0944	0.066655
13	15	3	0.09431	0.066902
15	16	2	0.094709	0.06683
11	13	4	0.094734	

PSO Bus selection in max. load.

As the above table shown the optimum location in max. load is **bus #12**.

Minimum load case:

# Bus	Voltages	P.F	Total P loss	Total Q loss
12	24	8	0.003887656	0.002744823
13	14	7	0.00388864	0.002745419
14	13	6	0.003911429	0.0027532
15	12	5	0.00391135	0.002751781
16	18	15	0.003910106	0.002745546
18	18	7	0.003908988	0.002744918

PSO Bus selection in min. load.

As the above table shown the optimum location in min. load is **bus #12**.

To sum up, we can notice that **bus #12** is the optimum location in the both situation.

Part 2:

Discussion:

As we mentioned in the previous chapter that the optimum sizing was 1.5 MW in max. load and 218.7 KW in min. load and the optimum location was bus #12, the effects for this adding on the main feeder as the following:

Month	Solar Radiation (W/m²)	Voltage Profile (P.U)	Total Power Factor	P Generation (MW)	P PV (MW)	Q Generation (MVAR)	Total P Loss (MW)	Total Q Loss(MW)
Jan	208.3	0.9965	0.895	1.72	0.158	0.859	0.005	0.003
Feb	263.6	0.9966	0.89	1.678	0.199	0.859	0.004	0.003
Mar	362.8	0.9968	0.882	1.608	0.269	0.858	0.004	0.003
Apr	464.2	0.9848	0.945	10.04	1.253	3.049	0.1001	0.071
May	552.6	0.9853	0.942	10.035	1.456	3.045	0.095	0.068
Jun	598.7	0.9856	0.941	10.033	1.55	3.044	0.093	0.066
Jul	585.6	0.9854	0.942	10.034	1.495	3.045	0.094	0.067
Aug	528.8	0.985	0.944	10.038	1.349	3.047	0.098	0.069

Sep	449.6	0.9845	0.946	10.042	1.163	3.05	0.102	0.073
Oct	335.1	0.9967	0.886	1.639	0.238	0.858	0.004	0.003
Nov	242.1	0.9966	0.893	1.7	0.177	0.859	0.004	0.003
Dec	191.4	0.9965	0.896	1.734	0.143	0.859	0.005	0.003

Table 8.1 The effects of add DG PV on bus 12

The power factor at the main feeder (Ayash Feeder) after add DG PV as the following fig. 8.1:

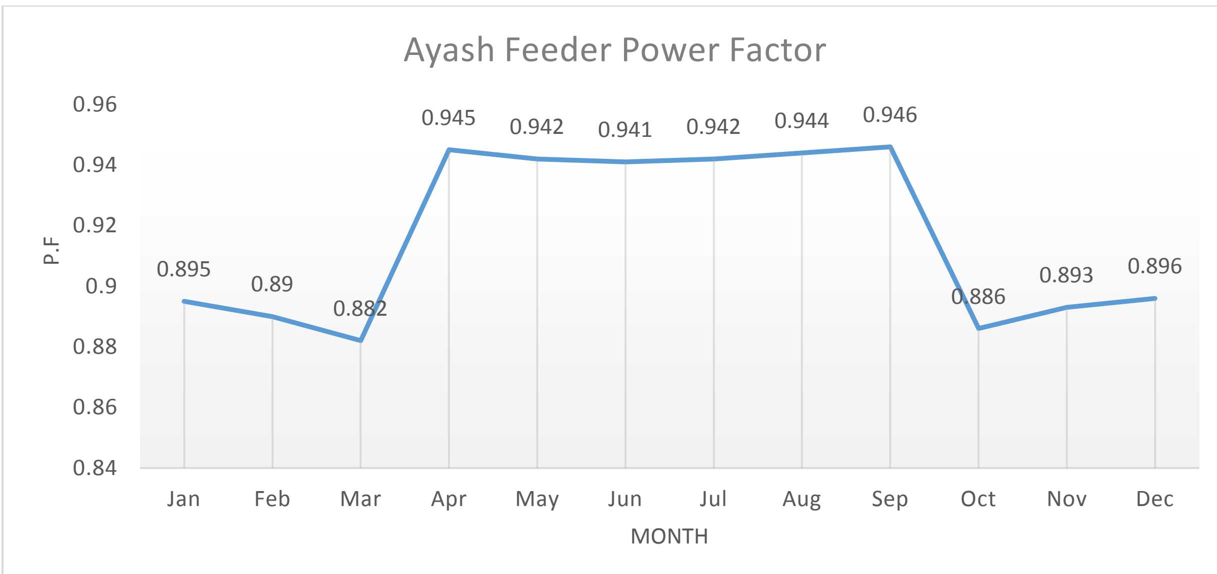


Fig 8.1 The power factor at the main feeder after add DG PV on bus 12

The total real power feed the all over main feeder (Ayash Feeder) after add DG PV as the following fig. 8.2:

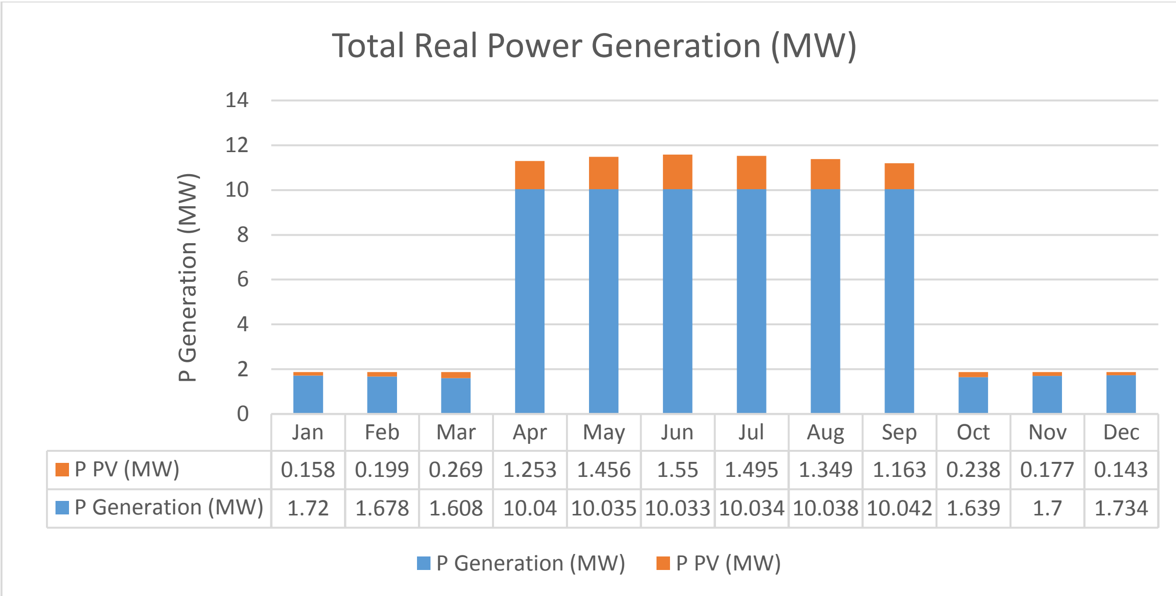


Fig 8.2 The total real power feed the all over main feeder after add DG PV on bus 12

Average Power=6.6459 MW, Max. Power=10.042 MW, Load Factor=66.18 %

The total Reactive power feed the all over main feeder (Ayash Feeder) after add DG PV as the following fig. 8.3:

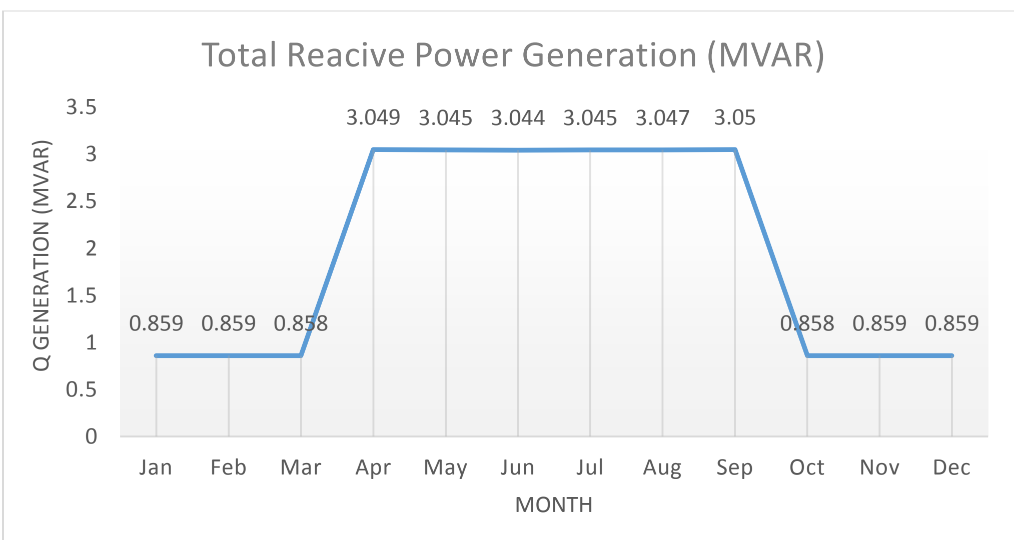


Fig 8.3 The total reactive power feed the all over main feeder after add DG PV on bus 12

The total real power and reactive power loss for the all over main feeder (Ayash Feeder) after add DG PV as the following fig. 8.4:

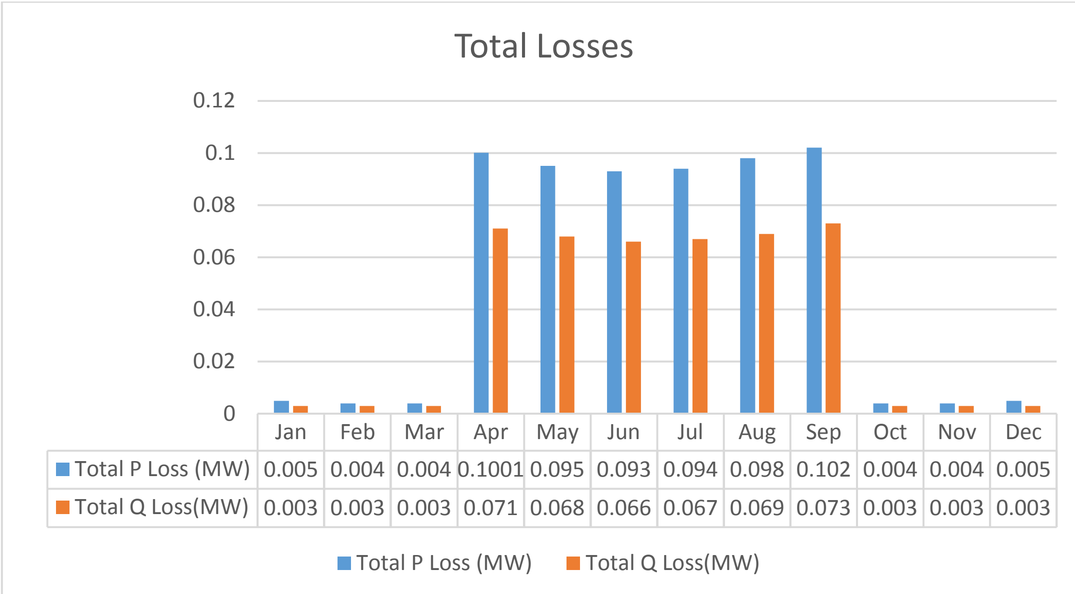


Fig 8.4 The total real power and reactive power loss for all over main feeder after add DG PV on bus 12

We can notice from the previous results that:

- The power factor at the main feeder sharp decrease
- The voltage profile at the main feeder gradual increase
- The reactive power generation constant
- The real power came from connection point steady decrease
- The total real and reactive power losses within the system decrease
- The load factor increase to become 66.18% from 59.32%

But, the effects on bus #12 as the following figures, we can noticed that the power factor become unity and steady at 1, on the other hand the voltage profile sharp increased during the year:

The voltage profile for bus #12 after add DG PV as the following fig. 8.5:

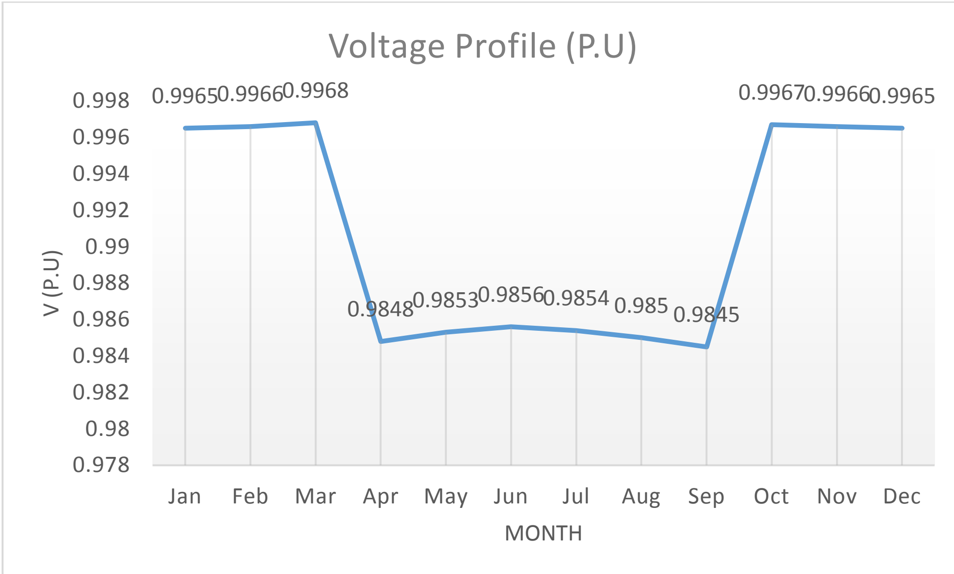


Fig 8.5 The voltage profile for bus #12 after add DG PV

The power factor at bus #12 after add DG PV as the following fig. 8.6:

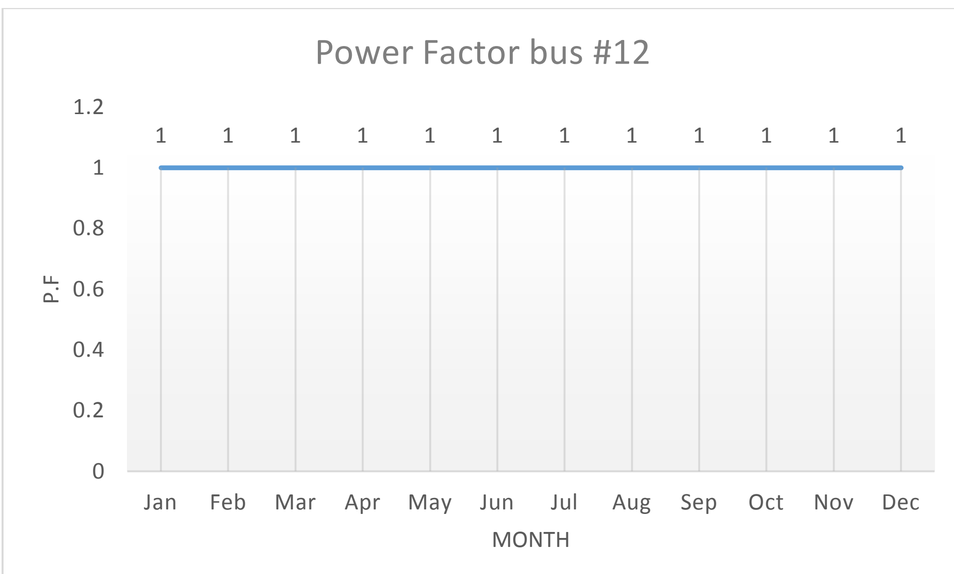


Fig 8.6 The power factor at bus #12 after add DG PV

Although, we studied the effects that appear in the all buses when we add DG PV on bus #12, the effects was the following figures and tables:

The following table 8. 2 shows the power factor in each bus before and after added DG PV:

# Bus	PF Original	PF After PV
1	0.909	0.885867
2	0.8917	0.408423
3	0.911	0.654792
4	0.853	0.7676
5	0.934	0.7532
6	0.889	0.64617
7	0.93	0.7979
8	0.912	0.80946
9	0.767	0.643
10	0.707106	0.589
11	0.952	0.6696
12	0.891	1
13	0.879	0.699784
14	0.878	0.607558
15	0.926	0.7217
16	0.855	0.74
17	0.879	0.621
18	0.891	0.6313
19	0.899	0.75
20	0.939	0.617
21	0.903	0.76238
22	0.857	0.6685
23	0.953	0.7402
24	0.908	0.646
25	0.866	0.6159

Table 8.2 The power factor in each bus before and after added DG PV

The affects for added DG PV on bus #12 on the power factor for each bus as the following:

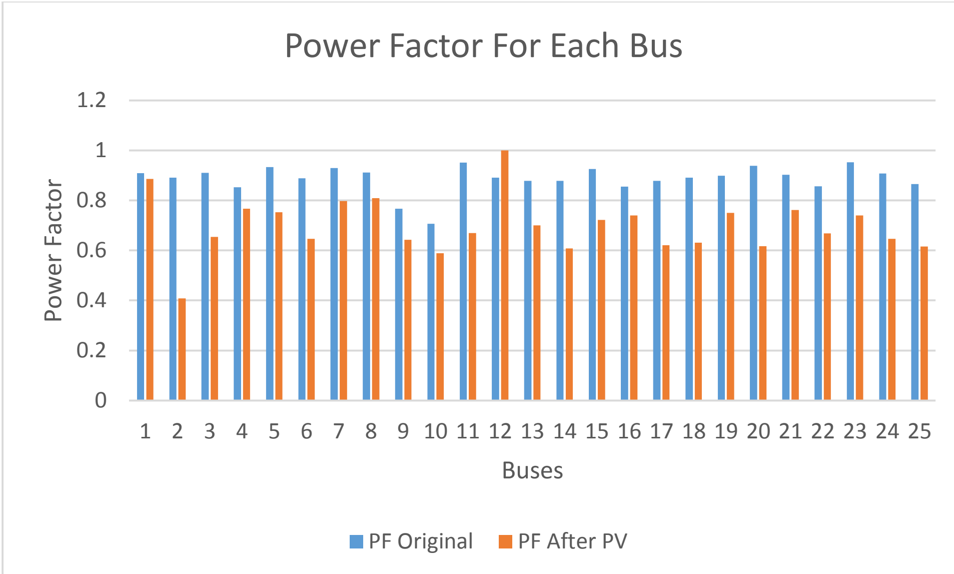


Fig 8.7 The affects for added DG PV on bus #12 on the power factor for each bus

The following table shows the Voltage profile in each bus before and after added DG PV:

# Bus	V original	V after PV
1	1	1
2	0.98889624	0.989987
3	0.98886	0.989765
4	0.98575	0.9872
5	0.98597	0.9875
6	0.985	0.98703
7	0.9848	0.986571
8	0.9835532	0.98567
9	0.9827	0.985091
10	0.9819987	0.98459
11	0.981849	0.984533
12	0.98122843	0.984512
13	0.98099	0.984278
14	0.98093	0.984217
15	0.98177123	0.984363
16	0.98127757	0.98387
17	0.98117745	0.98377
18	0.9811353	0.983728
19	0.98093	0.983524
20	0.9887876	0.9899
21	0.9885	0.98964
22	0.988	0.98957
23	0.9883	0.989393

24	0.9821263	0.989304
25	0.98820786	0.989299665

Table 8.3 The Voltage profile in each bus before and after added DG PV

The affects for added DG PV on bus #12 on the voltage profile for each bus as the following:

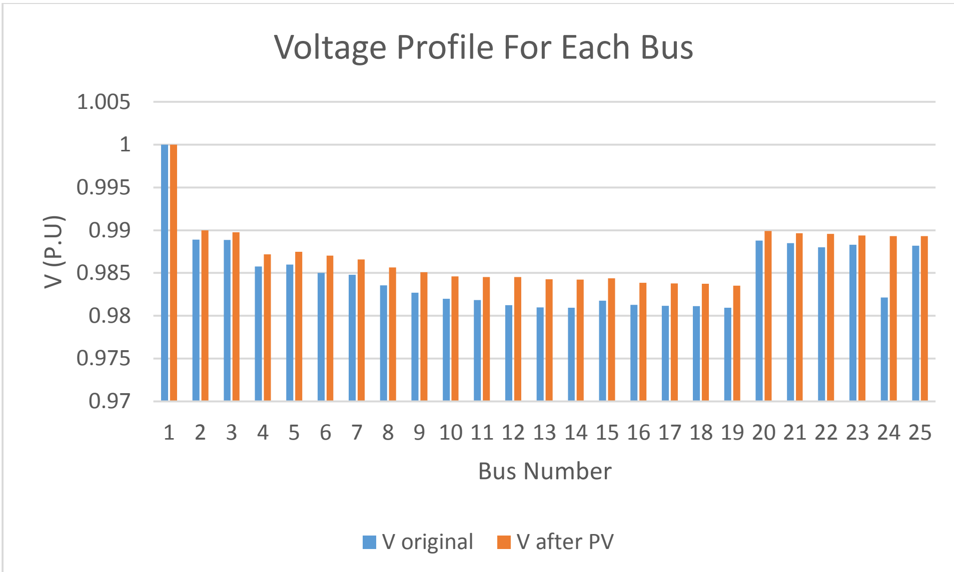


Fig 8.8 The affects for added DG PV on bus #12 on the voltage profile for each bus

The following table shows the total harmonic distortion (THD) in each bus before and after added DG PV to bus #12:

Bus Num.	Voltage harmonic Before (%)	Voltage harmonic After (%)	Current harmonic Before (%)	Current harmonic After (%)
1	5.42	2.6	11.94	6.32
2	5.32	2.45	11.67	6.8
3	6.85	4.2	8.66	4.6
4	5.26	3.2	11.65	6.3
5	6.35	3.85	7.43	3.5
6	6.22	3.8	10.68	5.02
7	6.96	4.3	7.35	3.4
8	5.62	2.55	10.67	5.01
9	5.36	2.35	9.85	4.8
10	5.68	2.45	10.67	5.1
11	6.52	1.98	7.45	3.6
12	6.35	2.7	7.41	3.8
13	5.59	2.89	10.68	4.89
14	4.99	2.12	11.94	4.52

15	5.26	3.2	9.54	4.98
16	6.53	2	8.56	4.6
17	5.33	2.3	9.53	4.88
18	6.43	2.82	7.42	3.89
19	6.42	2.86	8.52	4.99
20	5.95	2.15	9.53	4.62
21	5.69	2.23	10.69	5.08
22	5.2	3.1	11.68	6.2
23	5.36	3.21	10.66	5.6
24	4.98	2.5	9.53	4.9
25	5.96	2.3	10.68	5.6

Table 8.4 The total harmonic distortion (THD) in each bus before and after added DG PV to bus #12

The Voltage Harmonic emission in the network after add DG PV to the bus #12 and how it effects on the THD as the following:

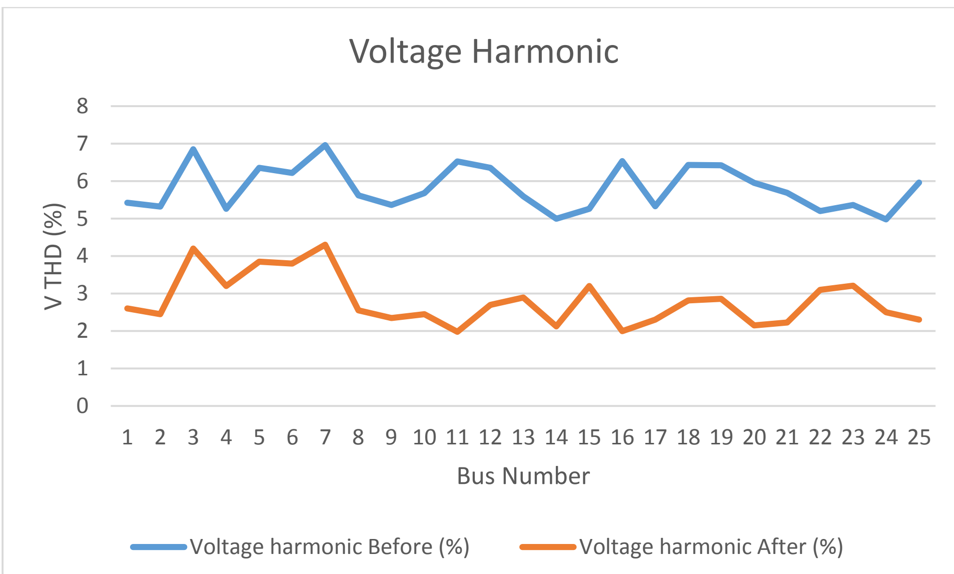


Fig. 8.9 The Voltage Harmonic emission in the network after add DG PV to the bus #12

The Current Harmonic emission in the network after add DG PV to the bus #12 and how it effects on the THD as the following:

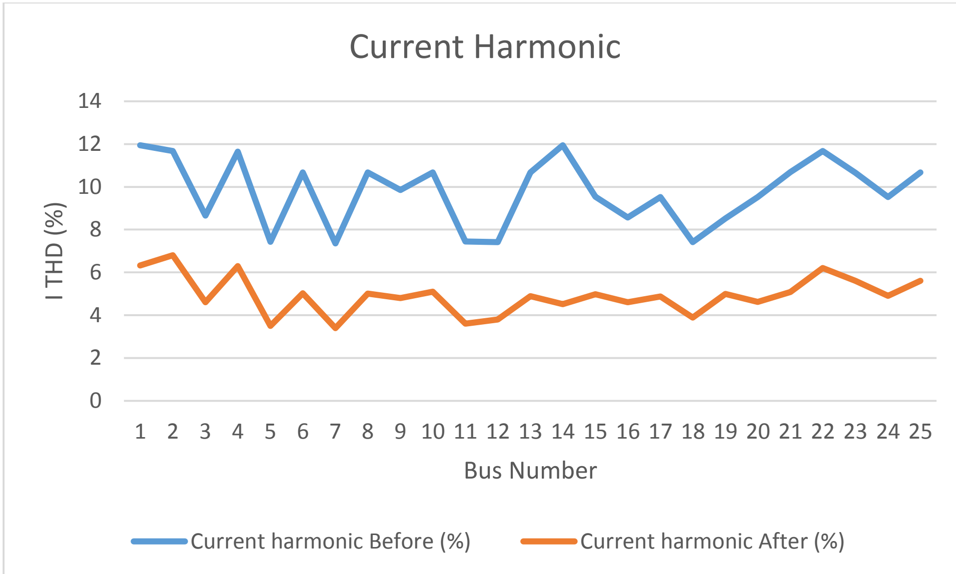


Fig. 8.10 The Current Harmonic emission in the network after add DG PV to the bus #12

We can notice from the previous results:

- The power factor at each bus sharp decrease
- The Voltage profile increase
- The total losses decrease
- The THD decrease for voltage and current signal

Part 3:

the one line diagram for An-Najah solar field that will feed Ayash feeder:

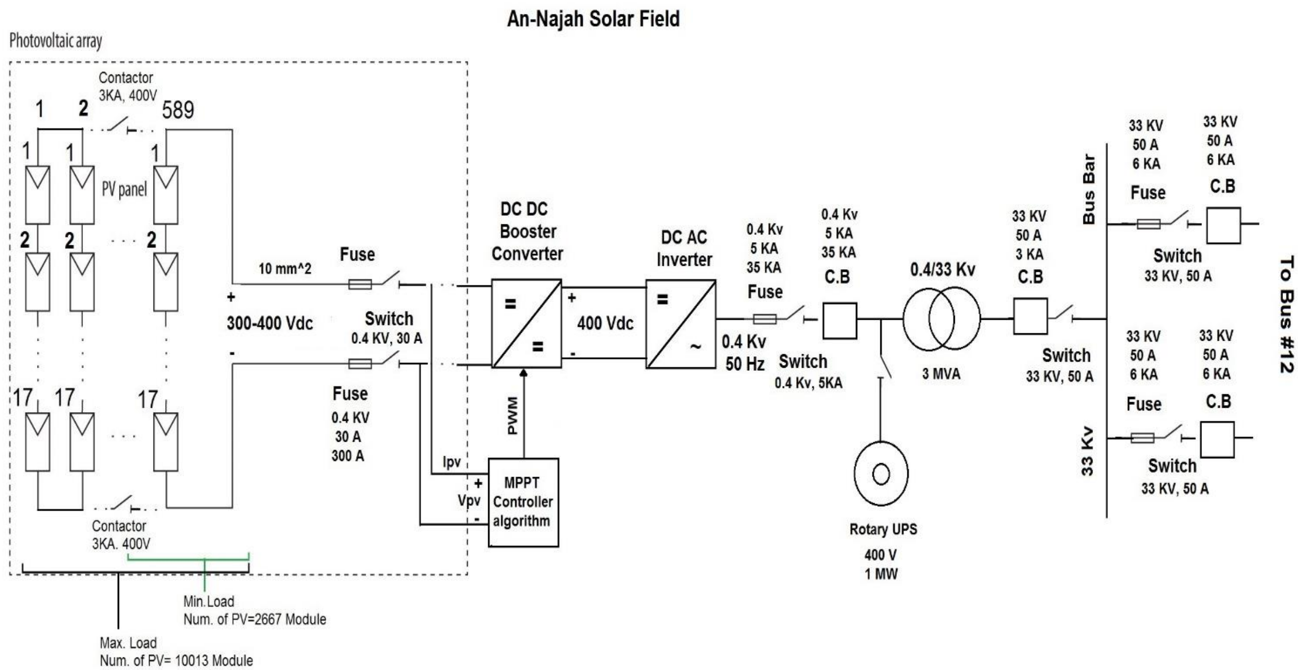


Fig. 7.3 An-Najah Solar Field.

Non Labor:

DC Components	V line (KV)	Nominal Current (A)	Breaking Capacity (A)	Unit	Price ($)/unit	Price ($)
Fuse	0.4	30	300	150	111	16650
Switch	0.4	30	-	150	64	9600
Contactor	0.4	3000	-	1	1400	1400
DC Wire, 10 mm^2	0.4	30	-	5000	4	20000
Total						**47650**

AC Components	V line (KV)	Nominal Current (KA)	Breaking Capacity (KA)	Unit	Price ($)/Unit	Price ($)
Fuse	0.4	5	35	1	14395	14395

Switch	0.4	5	-	1	7500	7500
C.B, SF6	0.4	5	35	1	18710	18710
C.B, SF6	33	0.05	3	1	29000	29000
Fuse	33	0.05	3	2	23000	46000
Switch	33	0.05	-	2	24500	49000
C.B, SF6	33	0.05	6	2	30000	60000
Bas Bur	33	0.1	-	1	5000	5000
Total						**229605**

Table 7.15 DC Components, properties, units and price [12]

Table 7.16 AC Components, properties, units and price [12]

Other Components	Properties	Unit	Price ($)/Unit	Price ($)
PV Module_SUNTECH	300W/24Vd	10013	250	2503250
Transformer_Schneider	0.4/33 KV , 3MVA	1	30000	30000
DC/DC Converter_ SMA	(300-400)V =400 V, 20000 W	150	500	75000
DC/AC Inverter _SMA	400 V = 400 V,50 Hz, 20000 W	150	1000	150000
Capacitor Banks_ABB	20KVAR, 400V	2	185	370
Capacitor Banks_ABB	25KVAR, 400V	9	200	1800
Capacitor Banks_ABB	30KVAR, 400V	13	264	3432
MPPT_SMA		150	100	15000
Motor	3 ph, 400 V, 10 Khp	1	10000	10000
Rotary UPS	400 V, 9 KAH	1	65000	65000
Total				**2853852**

Table 7.17 other Components, properties, units and price [8,11,12,13]

Assets	Area	$/Year	Year	Price ($)
Site	20 Dunam	75000	20	**1500000**

Table 7.18 Assets, properties, duration and price

DC Components	**47650 $**
AC Components	**229605 $**
Other Components	**2788852 $**
Site	**1500000 $**

Total ($)	**4541107 $**

Table 7.19 Total Non-labor resource Cost.

Labor:

Person	Num.	$/Hour	Hours/ 18 Months	Price ($)
Engineers	7	45	4320	194400
Technicians	20	23	4320	99360
Others	10	15	5000	75000
Total ($)				**368760 $**

Table 7.20 Total labor resource Cost.

Labor	**368760 ($)**
Non Labor	**4631107 ($)**
Currency Diffusion	**133 ($)**
Total Budget ($)	**5000000 ($)**

Table 7.21 Total Capital Cost.

The annual saving for Ayash Feeder:

Original:

The annual max demand:

Pmax= 10.076 MW

Since the load factor (L.F) = 59.32 %

$$Pavg = L.F * Pmax$$

$$Pavg = 0.5932 * 10.076 * 10^3 = 5977\ KW$$

$$Energy\ (E) = Pavg * 8760 = 52359249\ KWH\ yearly$$

The cost per KWH is 0.62 NIS/KWH:

$$Total\ bill = E * \ 0.62\ \ NIS/KWH = 32462734\ NIS\ per\ year$$

Since the power factor during the minimum load period less than 0.92 so the company is paying a penalty as explained below:

$$Energy/month = Pavg * 8760/12 = 4363271\ KWH\ monthly$$

$$cost\ per\ month = 2705228\ NIS\ per\ month$$

During the six month of minimum load the power factor =0.909

In Palestine the penalty for $0.8 \ \leq p.f \ \leq 0.92$ is 1% at total bill for each 0.1 under 0.92

0.92-0.909=0.011

$$Penalty\ per\ month = 0.011 * Total\ monthly\ Bill$$

$$Penalty\ per\ month = 0.011 * 2705228$$

$$= 29758\ NIS\ per\ month$$

For the six months:

$$Total\ Penalty = 6 * 29758 = 178548\ NIS$$

The total cost:

$$Total\ annual\ cost = Energy\ cost + total\ penalty$$

$$= 32462734 + 178548$$

$$= 32641282\ NIS$$

$$= \ \mathbf{9406710}\ \$\ \mathbf{.}$$

After using DG PV:

The annual max demand:

Pmax= 8.879 MW

Since the load factor (L.F) = 66.18 %

$$Pavg = L.F * Pmax$$

$$Pavg = 0.6618 * 8.879 \ * 10^3 = 5070.92\ KW$$

$$Pavg = 5070.92\ KW$$

$$Energy\ (E) = Pavg * 8760 = 44421259\ KWH\ yearly$$

The cost per KWH is 0.62 NIS/KWH

$$Total\ bill = E * \ 0.62 \ \ NIS/KWH = 27541181\ NIS\ per\ year$$

	Before using PV	After using PV
Total annual cost	32641282 NIS	27541181 NIS
Cost in $ (1$=3.47 NIS)	9406710 $	7936940 $

Table 7.22 Total annual Cost before and after add DG PV.

$$The\ yearly\ saving = 9406710 - 7936940$$

$$= \mathbf{1469770}\ \$$$

The Payback Period:

$$P.B.P = \frac{Capital\ Cost}{Saving}$$

$$P.B.P = \frac{5000000\ \$}{1469770\ \$}$$

$$P.B.P = 3.5\ Year$$

By the way the life cycle of the equipment in the solar field is about 20 Year and the payback period is 3.5 Year, so the total saving after 3.5 years of implemented this project will be

$$Saving\ after\ 3.5\ Year = (20 - 3.5) * Yearly\ Saving$$

$$Saving\ after\ 3.5\ Year = 16.5 * 1469770$$

$$Saving\ after\ 3.5\ Year = \mathbf{24251205}\ \$$$

To sum up, one can show that the project is feasible to implement.

Conclusions and Recommendation:

In general, we can conclude that this project will be a strong solution for this problem due to the improvement that happened after add DG PV on this feeder in Jenin City, especially in bus #12.

To sum up, the all effects on the system after add DG PV as the following:

- The voltage profile increase within the range (1.05≤ V ≤ 0.95) that can increase the efficiency of the supply from one hand, so the current in the system will decrease that mean the total losses will decrease, so the total bill will decrease, from the other hand we can use the same feeder to add new load within range that did not let the voltage be less than 0.95 P.U, so we can make a long term control without need new transformers.

- The total harmonic distortion in the system will decrease it can be seen that only the 12th, 15th, 18th, 21st and 24th harmonics exceeded the threshold limits. However, total voltage harmonics distortion for all of the studied cases is within the Australian regulatory standard limit as stated in AS 4777 [10], total Harmonic Distortion gives us the information about the harmonic content in a signal w.r.t. fundamental component, so that mean increase the power quality for the supply.
- The total real and reactive power losses decrease sharply, due to increase the voltage profile and decrease the currents in the system in the same time.
- The total saving in the total bill will be about 24 Million $.
- The only bad effect for this solution was decrease the power factor in the system, so that mean the penalty will be huge, so we recommend to use capacitor banks to increase the power factor to be equal or more than 92%.

The recommendation to improve power factor is to use capacitor banks as the following:

# Bus	PF Original	PF After PV	Capacitor Bank (KVAR)
1	0.909	0.885867	20
2	0.8917	0.408423	30
3	0.911	0.654792	30
4	0.853	0.7676	25
5	0.934	0.7532	30
6	0.889	0.64617	25
7	0.93	0.7979	25
8	0.912	0.80946	20
9	0.767	0.643	30
10	0.707106	0.589	30
11	0.952	0.6696	25
12	0.891	1	0
13	0.879	0.699784	25
14	0.878	0.607558	30
15	0.926	0.7217	25
16	0.855	0.74	25
17	0.879	0.621	30
18	0.891	0.6313	30
19	0.899	0.75	25
20	0.939	0.617	30
21	0.903	0.76238	25
22	0.857	0.6685	30
23	0.953	0.7402	25

24	0.908	0.646	30
25	0.866	0.6159	30

Table 9.1 Improve power factor and the value of capacitor banks

By using the above values of capacitor banks that will increase the power factor to be at least 92%, on the other hand will increase the voltage at the bus but within the voltage rang.

Constraints:

As any problem in our life we will find the suitable solution for it in many terms to solve it from one side and to have the stability for this solution during a long term period, so in this case we will use **SMART** method to solve it.

SMART method means that the solution will be specific, measurable, achievable, realistic and have time frame to have long term solution for any problem.

So to satisfy this method we faced many constraints and the constraints in our project can be divided into four parts:

1. Leakage in Data base from the supplier.
2. Unrealistic solution for this problem.

3. No Palestinian Standers to assist our work
4. Suitable software that can help us.

We find the suitable solution for this constraints as the following:
1. Leakage in Data base from the supplier:

The leakage in data base was in the some loads data, cables used, records for some factors and the vision for solving this problem.
The solution was that we took the records for some these loads by ourselves under the supervision of supplier and we calculated the parameters for the cables used in the system.
2. Unrealistic solution for this problem:

The solution for the problem from the supplier is unrealistic that the solution was to increase the connection points that to feed the increasing in demand for this system.

3. No Palestinian Standers to assist our work:

There is no standers for this work from Palestinian government to assist our solution, so we used the Australian standers.

4. Suitable software that can help us:
Due to the huge budget needed for this solution, we can't implement samples as a test sample in the ground, so the software can help us to find the suitable solution, so to solve this problem we built MATLAB codes to simulate the reality for this solution.