Eco-energetic effect of hybridization between PV system and diesel generator to produce electrical energy in south-west of Algeria

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Abstract: - Remote and isolated regions to main electricity network are a very difficult and expensive task. In its isolated sites, diesel engine-based power generation is the main source of energy to meet their day-to-day electricity requirements. But, the regular diesel engine maintenance requirement, the increasing cost of diesel and its transportation to remote areas and pollution are the main drawbacks of such kind of system. Recently, the installation of renewable energy sources in these regions proved to be advantageous, as it results in to reduced dependency on the diesel engine and its associated problems. However, due to the intermittent nature of renewable sources, their reliability and functionality is still a major challenge. Moreover, the presence of non-linear current component due to domestic consumer load profile may further lead to poor power quality. The degradation of power quality in isolated network may result in to increased losses, mal operation or even destruction of certain devices and unstable network operation. To address all the above discussed issues, an isolated PV -diesel hybrid system is developed, in which the proposed system is developed and tested in MATLAB/ Rap Sim simulation study is carried out to validate the proposed control approach.

*Key-Words: I*solated site, Autonomous network, Hybrid system, PV-Diesel, Rap-Sim

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1 Introduction

In isolated or remote areas, the cost of expanding the power grid is prohibitive and the additional cost of fuel supply increases dramatically with isolation. The term "Hybrid Energy System" refers to generation systems of electrical energy using several types of sources. Our goal is to understand the different phenomena governing the transfer of power between conventional source, the photovoltaic and the load to then clear rules optimization. In this work we presented our model of simulation. We trained the model of such way to express and study our scenarios scenario based on a source mixes (diesel + Photovoltaic) in four seasons different and we have to take one week for every season as a duration of simulation.

2 Diesel generator description

A diesel generator is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. This is a specific case of engine-generator. Diesel generating sets are used in places without connection to the power grid, as emergency power-supply if the grid fails, as well as for more complex applications such as peak-lopping, grid support and export to the power grid. Sizing of diesel generators is critical to avoid low-load or a shortage of power and is complicated by modern electronics, specifically non-linear loads.

Fig. 1. Diesel generator.

TMP Scientific design and offer Stand-alone PV/diesel hybrid mini grid systems which powered by PV array with diesel generators and use DC&AC coupling configuration together for highest system performance.
Hybrid power systems have total power up to 100KVA, these hybrid systems generated electrical

energy from PV array to reduce the diesel consumption and continuous supply power to remote villages. This system could supply 1 kW electrical power with 8kWh of energy per one family. It provides electricity for improve quality of living and enhance opportunity to do more economic activities for remote area. The systems operate in fully automatic from black start with diesel generators to energize medium voltage transformer and distribution line after the system is energized and hybrid system supervisory controller found that load is low then it will switch to supply the mini grid by Bi-directional battery inverters and stop all diesel generator. During day time, grid connected inverter will feed energy from PV to the system at AC distribution line and these energies will flow to supply load directly and the excess energy can be used to charge battery. As system is designed to supply day time load by AC coupling thus most of energy at day time generated by AC coupling will be consumed by load with high conversion efficiency. The PV at DC coupling is connected to MPPT charger controller which will charge battery and in case that load consume power more than grid connected inverter can have generated then the balance will be from the DC coupling through bi-directional inverter.

3 Diesel and PV system hybridization

This hybrid system also operates with System Monitoring Unit and monitoring the system data and parameters, tracking and analyzing the system operation and efficiency any time.

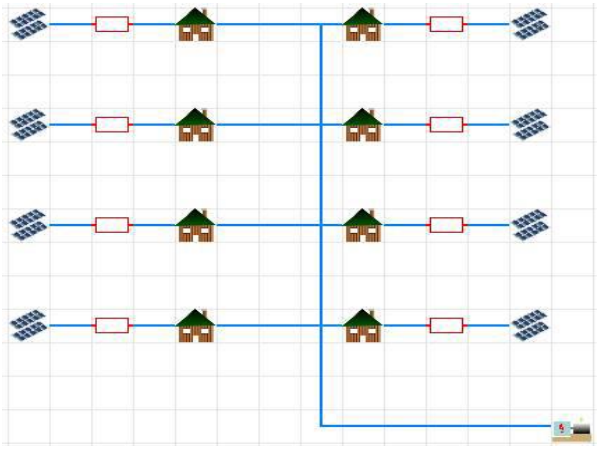


Fig. 2. Topography of Power Systems Combining PV and diesel generator.

Table. 1. Chosen of value of PV panel

Efficiency	0.2	% /100
Height	0.01	km
Latitude	46.6	°
longitude	14.4	°
Peak power	1500.0	W
Square meters	16.0	m²

The value used in this simulation based on conditions followed up as:
Attention these values are obtained by the builder in very particular conditions: the conditions of standard test: STC that is with an equivalent period of sunshine in 1000W/m² with a temperature of 25° it is condition STC is thus optimal.

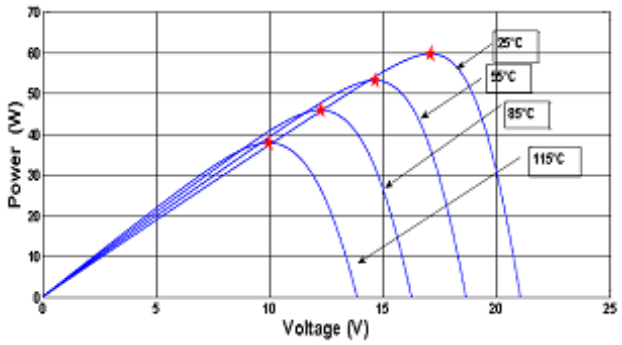


Fig. 3. Temperature effect on PV curve at constant irradiance (1000W/m2)

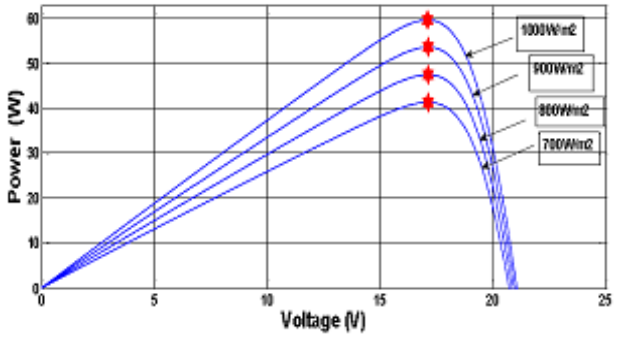


Fig. 4. Irradiance effect on PV characteristics at temperature (25°C)

The power of a photovoltaic panel (in kW, kilowatts) measures its production capacity of electricity. It is the technical characteristic which depends only on the panel in himself, and not on the place where he is put. Thus the power is determined by the material which establishes the solar panel and by its surface. Thus the most current installations

make from 1,5 to 3 kW, that is from 15 to 30 m ² of panels.

4 Atmospherics characteristics:

Air temperatures have their origin in the absorption of radiant energy from the Sun. They are subject to many influences, including those of the atmosphere, ocean, and land, and are modified by them. As variation of solar radiation is the single most important factor affecting climate, it is considered here first.

The radiant energy reaching the top of the atmosphere, 46% is absorbedby Earth's surface on average, but this value varies significantly from place to place, depending on cloudiness, surface type, and elevation. If there is persistent cloud cover, as exists in some equatorial regions, much of the incident solar radiation is scattered back to space, and very little is absorbed by Earth's surface

Table. 2. Characteristics of air temperature, daily solar radiation and the Earth temperature

month	Air temperature	Daily solar radiation	Earth temperature
January	12,4	4,42	13,3
February	16	5,22	16,8
March	19,4	6,5	21,8
April	23,6	7,22	27,3
May	28,1	7,67	32,4
June	33,6	8,14	37,6
July	36	8,03	39,7
August	35,4	7,56	38,9
September	31,6	6,5	34,9
October	25	5,36	28
November	18,2	4,42	20,4
December	12,9	3,83	14,8

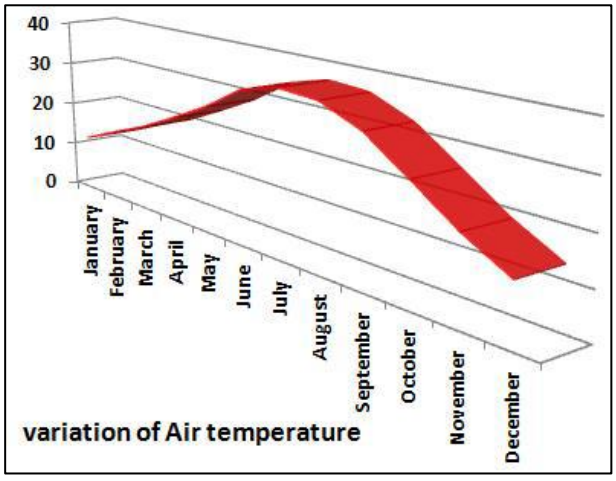


Fig. 5. Variation of air temperature

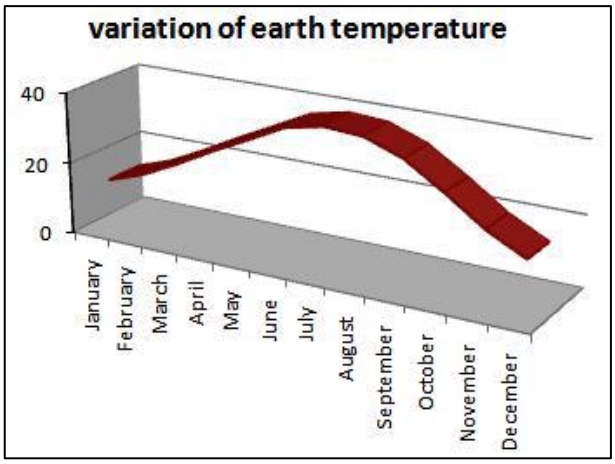


Fig. 6. Variation of earth temperature

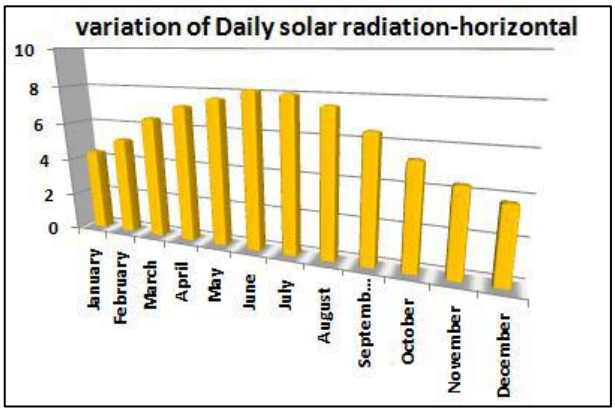


Fig. 7. Variation of daily solar radaiation-horizontal

5 Simulation results

For the simulation of our model for smart grid we choose a program the program is a java application named RAPSIM (renewable alternative power system simulation) we run this application with the eclipse interface.

Fig. 8. Interface of RAPSim simulator

RAPSim is a Java software project developed at the Smart Grid Group. The main goal is to provide a simple to use simulation environment for smart grid scenarios.

In this work we presented our model of simulation. We trained the model of such way to express and study two scenarios in four season different.
We quoted the scenarios as the continuation:
1. The first scenario based on a source of only diesel nature
2. The second scenario based on two source mixes (diesel + Photovoltaic)

5. 1. Scenario 1: Diesel only

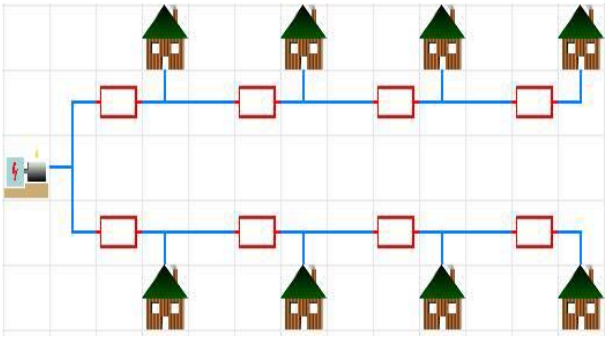


Fig. 9. The utilization of a diesel only into smart grid

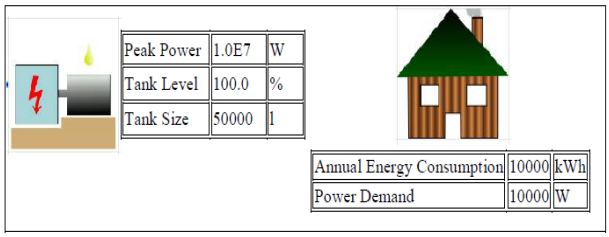


Fig. 10. Chosen a value of load and peak power for diesel

5.1.1. Winter

Table.3. Variation of load and fuel consumption on Winter

Time (H)	Tank level (%)	Consumption T
00:30	99,8	4874
01:30	99,6	3666
02:30	99,4	3248
03:30	99,2	3118
04:30	99	3084
05:30	98,8	3564
06:30	98,4	13261,6
07:30	97,4	8068
08:30	97	10712
09:30	96,8	11624
10:30	95	12064
11:30	94.1	13504
12:30	93,4	13504
13:30	92,7	12784
14:30	91	11832
15:30	90,4	11336
16:30	89,6	12658
17:30	89,2	15996
18:30	87	16984
19:30	86,7	15968
20:30	85	11862
21:30	84,7	10188
22:30	84	9212
23:30	84	9212

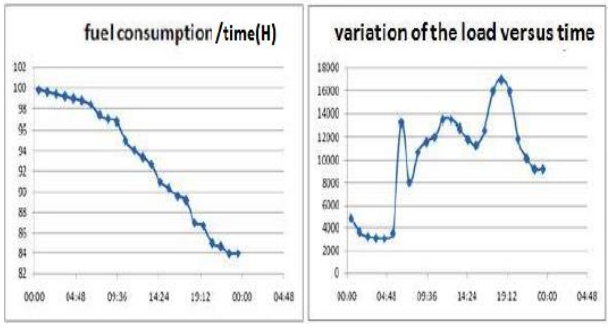


Fig. 11. Variation of load and fuel consumption on Winter

5.1.2. Spring

Table.4. Variation of load and fuel consumption on Spring

Time (H)	Tank level (%)	Consumption T
00:30	99,6	5912
01:30	99,4	4522
02:30	99,2	7242
03:30	99	4006
04:30	98,8	4064
05:30	98,6	4430
06:30	98,4	6134
07:30	98	8878
08:30	97	11504
09:30	94	13000
10:30	93,6	13342
11:30	93,1	14176
12:30	92,7	14568
13:30	92	13316
14:30	91,5	12086
15:30	91	11732,4
16:30	90,5	11598
17:30	90	12536
18:30	89,4	14030
19:30	89	14366
20:30	88,4	13036
21:30	88	11972
22:30	87	11326
23:30	87	11326

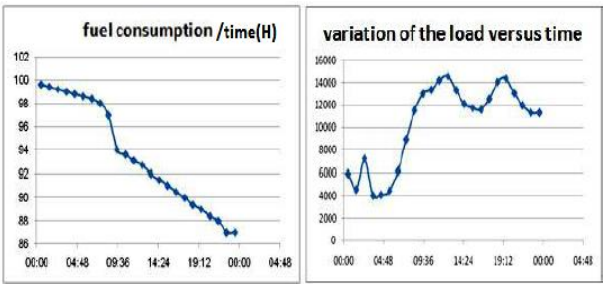


Fig. 12. Variation of load and fuel consumption on Spring

5.1.3. Summer

Table.5. Variation of load and fuel consumption on Summer

Time (H)	Tank level (%)	Consumption T
00:30	99.6	4890
01:30	99.4	4152
02:30	99.2	3838
03:30	99	3764
04:30	98.8	4168
05:30	98.4	5992
06:30	96	9450
07:30	95	10904
08:30	93	11560
09:30	92	11328
10:30	89	11064
11:30	86	11944
12:30	80	12792
13:30	79.4	11320
14:30	79.1	9936
15:30	79	9256
16:30	77	9364
17:30	75.2	10480
18:30	72.1	12360
19:30	69	13552
20:30	62.4	12920
21:30	60.4	12224
22:30	58.8	10528
23:30	58.8	10528

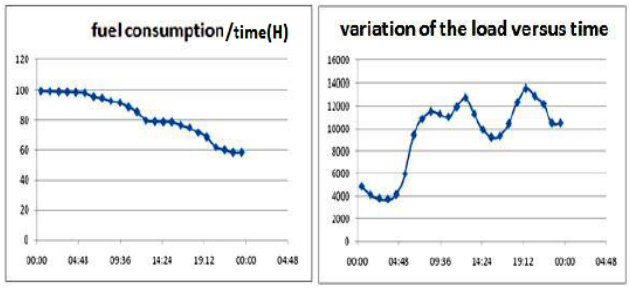


Fig. 13. Variation of load and fuel consumption on Summer

5.1.4. Autumn

Table.6. Variation of load and fuel consumption on Autumn

Time (H)	Tank level (%)	Consumption T
00:30	99	6169,6
01:30	98.8	4716
02:30	98.5	4164
03:30	98.3	4000
04:30	98.1	3968
05:30	97.8	3904
06:30	97.4	4618
07:30	97.2	7048
08:30	96	11040
09:30	94.8	14088
10:30	93.2	15676
11:30	92	16944
12:30	91.2	15688
13:30	90	12432
14:30	89.2	10766
15:30	89	9184
16:30	88.2	8524
17:30	88	9326
18:30	87.8	11150
19:30	87.5	12754
20:30	87.1	12418
21:30	86.5	11700
22:30	86.1	10212
23:30	86.1	10212

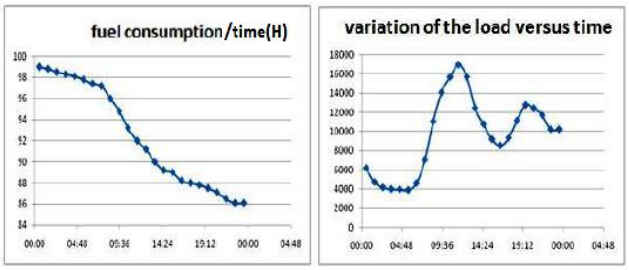


Fig. 14. Variation of load and fuel consumption on Autumn

The utilization of diesel generator only in four season is different according to the demand of the load in every season. We see that the consummation of diesel generator is higher in this scenario. We have seen that it is necessary to add another system to improve the performances of this scenario. For that reason, we have to make scenarios who allows us to integrate one or several renewable sources, then we have added in the next scenario a photovoltaic panel.

A photovoltaic panel combined a micro grid with houses and connect with a distribution network of source fossil.

5. 2. Scenario 2: Diesel and photovoltaic

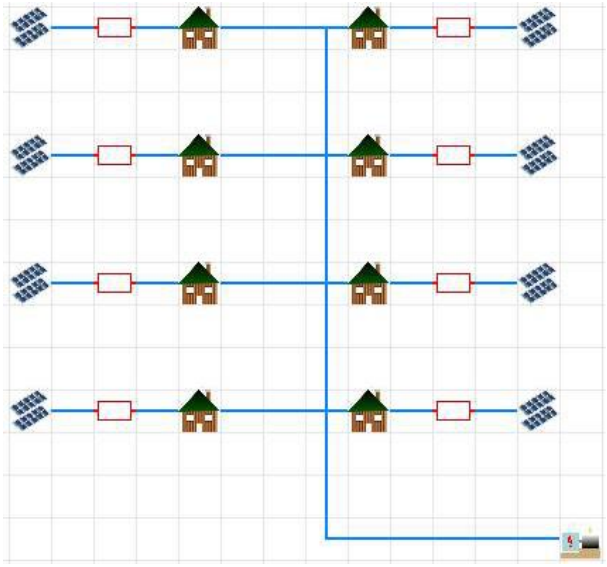
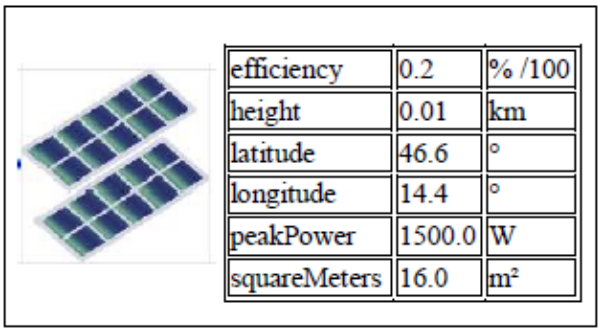


Fig. 15. Topography of Power Systems Combining PV and diesel generator



efficiency	0.2	% /100
height	0.01	km
latitude	46.6	°
longitude	14.4	°
peakPower	1500.0	W
squareMeters	16.0	m²

Fig. 16. Chosen of value of PV panel

5.2.1. Winter

Table.7. Variation of load and fuel consumption on Winter

Time (H)	Tank level (%)	Consumption T
00:30	99,6	4874
01:30	99,4	3666
02:30	99,2	3248
03:30	99	3118
04:30	98,8	3084
05:30	98,4	3564
06:30	96	13261,6
07:30	95	8068
08:30	94,7	10712
09:30	94,5	11624
10:30	94,3	12064
11:30	94,1	13504
12:30	93,8	13504
13:30	93,6	12784
14:30	93,5	11832
15:30	93,2	11336
16:30	92,8	12658
17:30	92	15996
18:30	91,5	16984
19:30	90	15968
20:30	89,7	11862
21:30	89,2	10188
22:30	88,8	9212
23:30	88,4	9212

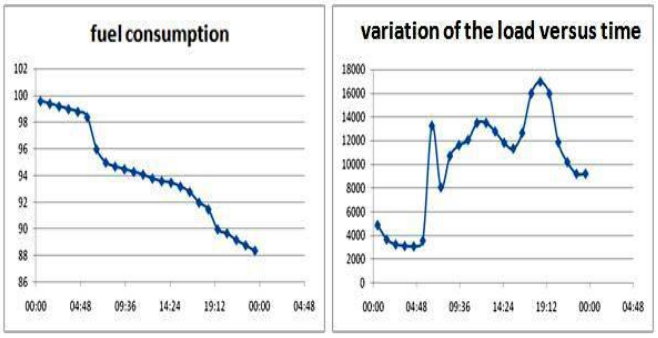


Fig. 17. Variation of load and fuel consumption on Winter

5.2.2. Spring

Table.8. Variation of load and fuel consumption on Spring

Time (H)	Tank level (%)	Consumption T
00:30	99,6	5912
01:30	99,4	4522
02:30	99,2	7242
03:30	99	4006
04:30	98,8	4064
05:30	98,4	4430
06:30	96	6134
07:30	95,5	8878
08:30	95,2	11504
09:30	95	13000
10:30	94,8	13342
11:30	94,6	14176
12:30	94,4	14568
13:30	94,2	13316
14:30	94	12086
15:30	93,9	11732,4
16:30	93,7	11598
17:30	93,6	12536
18:30	93,3	14030
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20:30	92	13036
21:30	91,2	11972
22:30	90	11326
23:30	90	11326

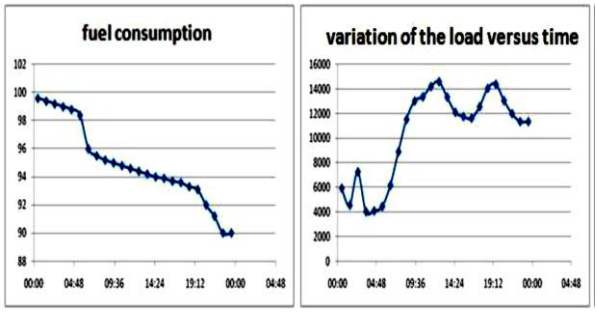

Fig. 18. Variation of load and fuel consumption on Spring

5.2.3. Summer

Table.9. Variation of load and fuel consumption on Summer

Time (H)	Tank level (%)	Consumption T
00:30	99,6	5690
01:30	99,4	4128
02:30	99,2	3838
03:30	99	3764
04:30	98,8	4168
05:30	98,4	5998
06:30	98,2	11424
07:30	98	12504
08:30	97,8	11560
09:30	97,6	11328
10:30	97,4	13504
11:30	97	13544
12:30	96,8	13592
13:30	96,5	11320
14:30	96,3	9936
15:30	96	11542
16:30	95,8	9360
17:30	95,6	10480
18:30	95,4	12360
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21:30	92	12228
22:30	91,3	10458
23:30	91	10458

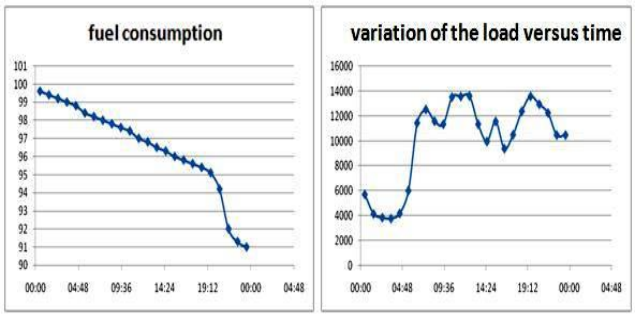

Fig. 19. Variation of load and fuel consumption on Summer

5.2.4. Autumn

Table.10. Variation of load and fuel consumption on Autumn

Time (H)	Tank level (%)	Consomption T
00:30	99,6	6169,6
01:30	99,4	4716
02:30	99,2	4164
03:30	99	4000
04:30	98,8	3968
05:30	98,4	3904
06:30	96	4618
07:30	95,5	7048
08:30	95	11040
09:30	94,8	14088
10:30	94,6	15676
11:30	94,4	16944
12:30	94	15688
13:30	93,9	12432
14:30	93,8	10766
15:30	93,6	9184
16:30	93,3	8524
17:30	93	9326
18:30	92,2	11150
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20:30	91,1	12418
21:30	91	11700
22:30	89,6	10212
23:30	89	10212

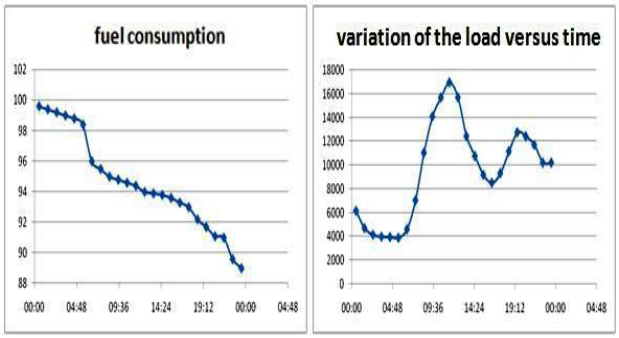

Fig. 20. Variation of load and fuel consumption on Autumn

The used of photovoltaic mixed with a diesel generator system allows we to decrease the consummation of diesel with a 4.4 % reduction in winter and 3 % in spring and 31.2 % in summer and 4.9 % in autumn. Concerning the improvement that we see in the second scenario about the fuel consumption we going to do a third experiment but this time we will integrate a wind turbine in the network is to see results concerning fuel consumption.

6 Conclusion

In this article we have highlighted the behavior of hybrid systems between PV systems and Diesel when connecting a load. Intelligent integration of distributed production, where many sources of energy will be dispersed along the transport, distribution network and customer domains. Some examples of distributed energy resources include solar energy panels. We note that integration offers us significant reductions in environmental impact, including both quantifiable benefits and no quantifiable benefits. Quantified environmental impact reductions in equivalent carbon dioxide emissions per customer per year are available the ideal case of the impact on conservation offered by Smart Grid capabilities such as integrated Volt / VAr control and rate varying over time.

Smart Grid capabilities also seem allow greater quantities of renewable production to be integrated by tackling intermittent and technical challenges. Although difficult to quantify, the environment the impact reductions of a greater quantity of renewable production are probably multiple greater than the quantified quantities of network capacity conservation effects.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

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Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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