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FUZZY LOGIC FOR DETERMINING THE POTENTIAL OF SOLAR ENERGY POWER PLANT IN SOUTH LIBYA

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Abstract

Energy models also help in integrated assessment considering availability, potential, economics, emission, technology, social acceptance etc Libya is an oil exporting country located in the middle of North Africa, with 6 million inhabitants distributed over an area of 1,750,000 Km2. The problem of this research is the potential of solar energy that is used can be used to overcome the energy needs in South Libya where people are densely populated but need a lot of electrical energy. The potential energy needs of electricity are big because south of Libya many densely populated people need big electricity. Also whether the function of Fuzzy logic is to be able to do the right way to map an input space into an output space based on the concept of fuzzy. The objective of this research is to analyse potential of solar energy generation using fuzzy logic in South Libya. The authenticity of this research is using fuzzy logic in South Libya to overcome the problem that is the demand of huge electricity from solar energy generation. This research is quantitative research with simulation or experimental research to make verification with MATLAB simulation (Fuzzy logic approach). In his research will cover in 7 days' simulation with Matlab, with Fuzzy logic approach, the target is to make simulation panel solar system in South Libya. The determination of potential solar energy power plant in South Libya using fuzzy logic can be seen in the simulation Matlab that proven the Fuzzy Logic approach have achieved the optimal solar energy power plant. The result showed that in Libya the consumption is 10020 MW with 3.504.000 homes and 2860 W, so need 67 solar panels. The low is when the humidity between 40%-60% (0.6 kW), Medium when the humidity 60%-80% (2.86kW) and High when humidity 80%-100% (3.9 kW).

1. Introduction

The sun is the object of the solar panel, so the solar panel must be able to follow the direction of motion of the sun so that the efficiency of the solar panel is maximized. And to be able to position the solar panel so that it is always perpendicular to the sun, it needs a solar panel that can be controlled. Modelling is done by deriving mathematical equations from the constituent parts which are the movers of solar panels. Solar energy is a renewable energy source that is also the source of most other forms of energy on earth.

The amount of energy that is large and abundant makes solar energy very potential to be utilized. However, due to current technological limitations, only a small amount of energy can be extracted. For the photovoltaic case, the highest efficiency theoretically is 55%. although in practice it can be relatively much lower [1]. To increase solar energy extracts a sun tracker is used. Sun tracker is used to maximize the energy that can be received by solar panels by keeping the position of the solar panel so that it is always perpendicular to the light source. Mathematically and experimentally, the sun tracker is able to increase the amount of energy received up to 60% [2]. Various sun tracker systems have been developed by many researchers both using special algorithms while different types of sensors.

Energy models also help in integrated assessment considering availability, potential, economics, emission, technology, social acceptance etc. Econometric models deal with the costs of resources, energy systems, economy of the country, technological parameters etc. Energy-economic models are used to examine the wider impacts of changes in the energy system and the economy. Energy system models are technology-based cost optimizing models that are predominantly used for technology assessments. Energy-environment models help in understanding the linkage between energy use, greenhouse gas emissions and climate change. With several competing energy options, energy models based on fuzzy logic enable researchers to realistically select the right mix of energy resources considering the various conflicting criteria like costs, availability, emission etc [2].

Libya is an oil exporting country located in the middle of North Africa, with 6 million inhabitants distributed over an area of 1,750,000 Km2. The daily average of solar radiation on a horizontal plane is 7.1 kwh/m2 /day in the coastal region, and 8.1 kwh/m2 /day in the southern region, with average sun duration of more than 3500 hours per year [3]. The national electric grid consists of a high voltage network of about 12,000 km, a medium voltage network of about 12,500 km and 7,000 km of low voltage network [3]. The installed capacity is 5600 MW with a peak Load of 3650 MW, for the year 2004 [3]. In spite of that; there are many villages and remote areas located far away from these networks. Economically these areas cannot be connected to the grid, owing to its small population, and small amount of energy required, in the past these facts dictate the use of diesel generators as a power supply. The use of diesel generators need continuous maintenance, continuous supply of fuel, These reasons open the door to look into some other sources like renewable energy, moreover renewable energy provides clean and reliable energy sources which can be used in many applications in remote areas (electricity, water pumping, etc.). The use of renewable energies have been introduced in a wide applications due to its convenience use and being economically attractive in many applications, the most potential renewable energy sources are solar energy, wind energy, and biomass [3].

Photovoltaic conversion which is the direct conversion of solar energy to electricity may be the most reliable source for rural electrification. The use of wind energy to electrify remote areas will not be a reliable source as wind energy is not a continues supply, beside the use of wind source need maintenance personal, so this option will not be a reliable power supply in remote areas for developing countries. Biomass energy sources are limited to small applications of individuals as an energy source but not as electricity source [3].

For Libya the conventional sources of energy are limited to two sources: (1) Oil with a total discovered resources estimated by 40 billion bbl. (2) Natural Gas with a total discovered resources estimated by 1300 billion m3. The oil resources for Libya will not last more than 50 years as of today production and discovered resources, while the natural gas is expected to last more than that. Libya is an oil exporting country and most of the produced energy is exported.

2. Research System Overview

In this work, potential of the solar energy is investigated. Figure 3.1 has shown the general problem gap that happened in the Libya. There’re demands gap to the supply of the electric power in the Libya. Deficit of the supply trying to solving by proposing of the energy resource that’s available in the Libya, such as solar energy. To mitigate supply of the energy gap in Libya, solar potential is deeply exploration and in order to explore the measurement metric, fuzzy logic is proposed.

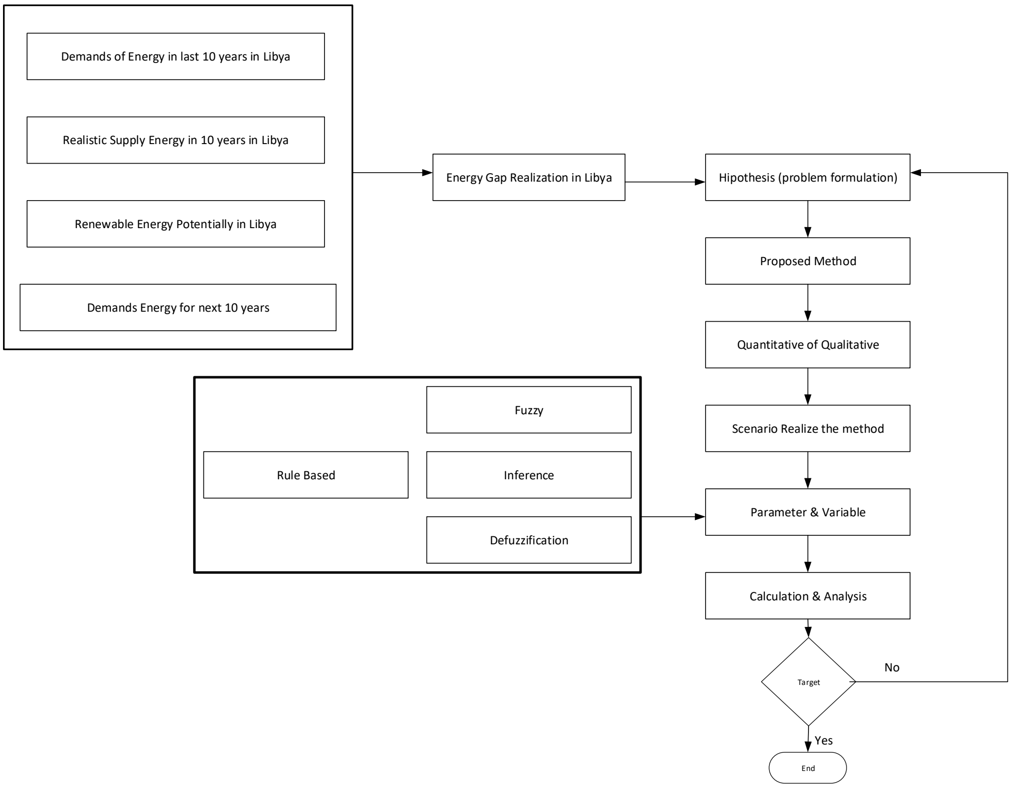


Figure 1 Research System Overview

From the problem formulation in Figure 3.1, the availability of solar resources in Libya makes the opportunity to use solar energy for electricity very large. However, until now, due to unfavorable conditions and situations, opportunities for developing solar power plants have become constrained. Another obstacle is sunlight radiation to ambient temperature which affects the absorption of photons in the PV panels, making production not optimal. In the peninsula of East Africa, sun rays contain> 70% heat. As a result, electricity production will depend on temperature conditions and heat absorbed by the solar panels. to overcome this, we need a strategy that can bridge the shortcomings of this condition. In this thesis, a combination of temperature, radiation emission, and the area of land used for solar panels will be carried out. thus with a limited beam, the extreme temperature will be overcome by the area of land used to produce the targeted electrical energy**.**

3. Research System Model

Here, will describe briefly about the structure of a solar power plant. Figure 3.2 shows the structure of the production of solar-based electrical elergy, which begins with the emission of solar radiation, then absorbed by the solar panel, then the photons will be converted into electrical energy, the current generated by the solar panels will be flowed to the battery. At this stage a problem will arise, namely if the power capacity is 240 watts, then the solar panel should work at a voltage of 29.7V and a current of 8.1 A according to the calculation of the panel power capacity, namely Vmax * Imax, but in practice in the field charging current to the battery will depend on the existing voltage on the battey, so the solar panel operating voltage will follow the battery voltage at a voltage of 12V. Then the solar panel output voltage will drop dramatically to 12V * 8.1 A = 97.2 W.

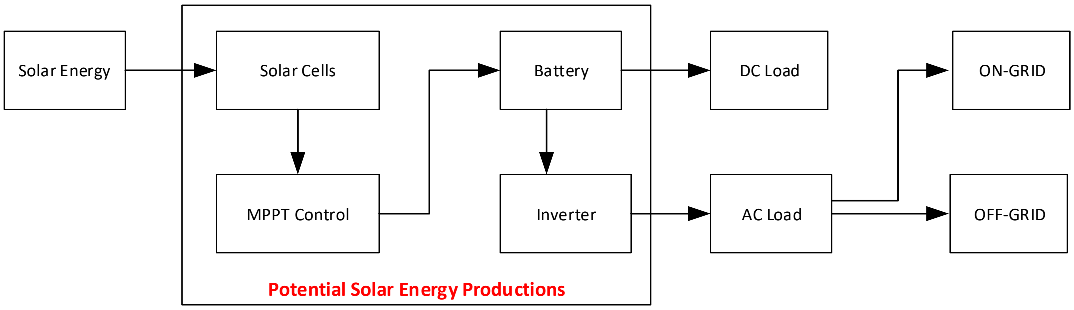


Figure 2. Overview of the solar power plant with on-grid dan off-grid connection

The amount of power loss in the solar panels makes electricity production not optimal. To overcome this, the maximum power point tracking (MPPT) is used. This device is used to overcome the problem of energy shrinkage by adjusting battery charging which can optimize the performance between the solar array (PV panel) and the battery bank. In other words, this tool is able to convert the high voltage DC output from the solar panel to the lower voltage required by the battery / battery bank. In this charging process, the MPPT mechanism also increases the DC current (amperage) which is charged to the battery / battery bank. The next stage is distribution to the load for DC loads can be channeled directly through the battery, and the AC load must go through the inverter.

At this stage, as shown in Figure 3, there are 3 parameters used, namely solar radiation (CI), temperature (T) and land area (W) used. As a variable that affects input parameters is the demand for electrical energy production or demand (D). So that it can be modeled in novel equation as follows:

$$Demands = \left(\frac{(Solar\ Radiation * 0{,}7) * Temperature * Wide\ of\ land}{Supply\ (W)}\right)$$

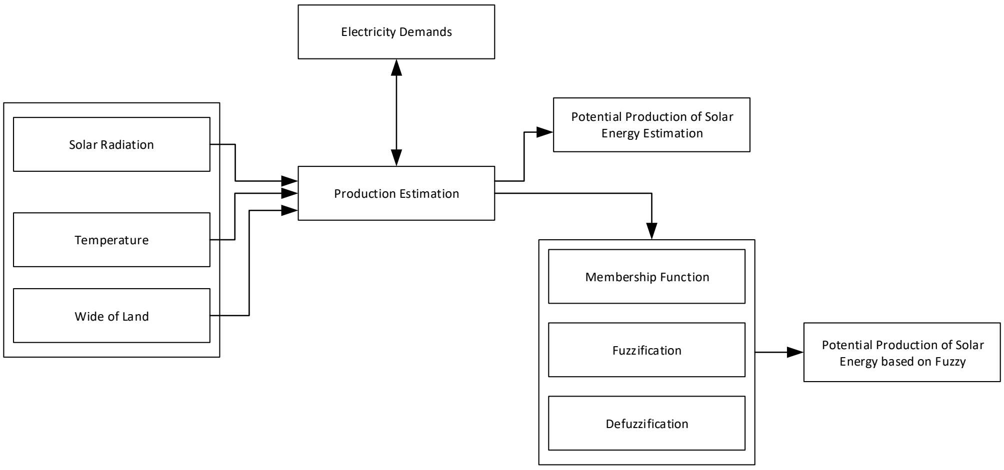


Figure 3. Fuzzy logic algorithm for potential solar energy power in Libya

These 3 parameters will generate electricity production, then the calculation comparisons are carried out with the application of fuzzy logic on these 3 parameters. Thus, it will be seen the comparison of the calculation results between the conventional model and the fuzzy algorithm in determining the potential for electricity generation based on solar energy.

Tools or material used is the simulation of Fuzzy Logic and analysis using Matlab program based on Mamdani model. There are 3 parameters inputs that influence of the performance output. The parameters are solar radiation; temperature; and wide of land used (m^2). The variable outputs variable is power production estimation (Watt). The solar radiation is provide as averaged data sequential in a year, such as follows:

Table 1 Solar Radiation

Months	Clearness Index	Daily Radiation (kWh/m^2/d)
January	0.64	4.34
February	0.66	5.56
March	0.64	5.89
April	0.64	6.01
May	0.67	7.38
June	0.67	8.21
July	0.69	8.05
August	0.69	7.96
September	0.67	6.25
October	0.66	5.89
November	0.68	4.54
December	0.69	4.17

From Table 1 an averaging of solar radiation calculates as follow:

$$\mu = \frac{\sum Clearness\ Index}{Number\ of\ Months} = \frac{0,64+0,66+0,64+0,64+0,67+0,67+0,69+0,69+0,67+0,66+0,68+0,69}{12} = 0,666$$

1st, calculate deviation standard

$$\sigma^2 = \frac{(\bar{X}-\mu)^2}{n-1} = 1,79$$

Find value of Z using this equation of $Z = \frac{X-\mu}{\sigma}$ and probability value of P(Zn):

$$Z_{0,64} = \frac{0,64-0,66}{1,79} = -0,011 \qquad P(Z_{0,64}) = 0,4960 * 100\% = 49,60\%$$

$$Z_{0,67} = \frac{0,67-0,66}{1,79} = 0,005 \qquad P(Z_{0,67}) = 0,5199 * 100\% = 51,99\%$$

$$Z_{0,69} = \frac{0,69-0,66}{1,79} = 0,016 \qquad P(Z_{0,69}) = 0,5080 * 100\% = 50,80\%$$

$$Z_{0,68} = \frac{0,68-0,66}{1,79} = 0,011 \qquad P(Z_{0,69}) = 0,5040 * 100\% = 50,40\%$$

Therefore, it’s knowing solar radiation probability as follow:

$$P(X \geq 0,64) = 1 - P(X \leq 0,64) = 1 - P\left(Z_{0,64}\right) = 1 - 0,4960 = 0.504 = 50,4\%$$

$$P(X \geq 0,67) = 1 - P(X \leq 0,67) = 1 - P\left(Z_{0,67}\right) = 1 - 0,5199 = 0.4801 = 48,01\%$$

$$P(X \geq 0,69) = 1 - P(X \leq 0,69) = 1 - P\left(Z_{0,69}\right) = 1 - 0,5080 = 0.496 = 49,6\%$$

$$P(X \geq 0,68) = 1 - P(X \leq 0,68) = 1 - P\left(Z_{0,68}\right) = 1 - 0,5040 = 0.492 = 49,2\%$$

The optimal need for solar panels can be seen from the probability value obtained is 50.4%, seen from the solar insolation graph, the probability value for solar insolation is more than 0.64 kW/m^2.

Table 2 PV panel specification

Power Output (W)	250
Voltage at Pmax (Vmp)	31,2
Current at Pmax (Imp)	8,02
Open-circuit current (Voc)	37,9
Short-circuit current (Isc)	8,56
Dimensional Modul	1650 mm x 992 mm

$$P_{maxmodul} = V_{mp} * I_{mp} * FF$$

$$Fill\ Factor = \frac{V_{mp} * I_{mp}}{V_{oc} * I_{oc}} = \frac{31{,}2 * 8{,}02}{37{,}9 * 8{,}56} = 0{,}771$$

$$P_{maxmodul} = 31{,}2 * 8{,}02 * 0{,}771 = 192{,}992$$

$$P_{inmodul} = Radiation\ Intensity * wide\ of\ modul$$

$$P_{inmodul} = 0{,}64 * 1650 = 1050$$

$$\eta = \frac{P_{maxmodul}}{P_{inmodul}} x100\% = \frac{192{,}992}{1050} x100\% = 18{,}37\%$$

$$P_{outmodul} = A_{modul}\ x\ S\ x\ \eta = 1{,}636\ \text{m}^2\ x\ 0{,}64\ \text{kW/m}^2\ x\ 0{,}2 = 0{,}209\ \text{kW}$$

After getting the P$_{\text{outmodul}}$, the total module you are looking for is the following equation:

$$\sum modul = \frac{E_{total}}{P_{outmodul} x\ Radiation}$$

$$E_{total} = A * r * H * PR$$

$$E_{total} = 1{,}650 * 50{,}2 * 6{,}1857 * 0{,}75 = 3{,}842\ kWh$$

$$\sum modul = \frac{3{,}842}{0{,}209x\ 5} = 3{,}67\ \text{modul}$$

So that to produce 3,842 kWh it takes approximately 4 modules of PV panels. So that if the production target is 3MW, then a land area of 1000 m^2 is required.

4. The Potential Solar Energy Propose System Model Based On Fuzzy Logic

In this works, three parameters are proposed in order to performs solar power plant potential in Libya, such as temperature, solar radiation and wide of land.

In this scheme, a membership function based on sigmoid form of fuzzy sets, which shown in equation below:

μ [x;a,b,c]$_{\text{sigmoid}}$ = 0; x ≤a
2((x-a)/(c-a)$^{)2}$;a <x≤b
1 -2 ((c -x)/(c -a))^2; b <x <c
1; x ≥c

There are three variables to be modeled, with the membership numbers as follows:

1. Temperature; consists of 3 fuzzy sets, namely: LOW, NORMAL, and HIGH
2. Solar radiation; consists of 3 Fuzzy sets, namely: LOW, NORMAL, and HIGH
3. Wide of land; consists of 3 Fuzzy sets, namely: NARROW, NORMAL, and WIDTH

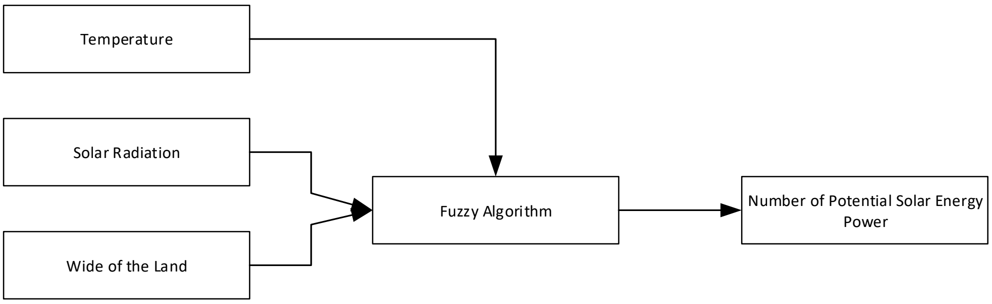
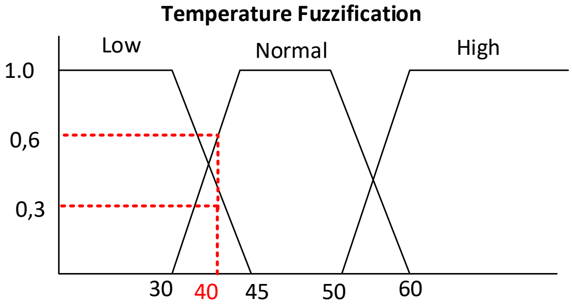


Figure 4 Fuzzy algorithm proposed model for potential solar energy power in Libya

a. **For the average annual temperature is 40 °C, the membership function describes as follows:**

$$\mu_{low}\left[40\left(\frac{m}{s}\right)\right]=\frac{45-40}{45-30}=0,3$$

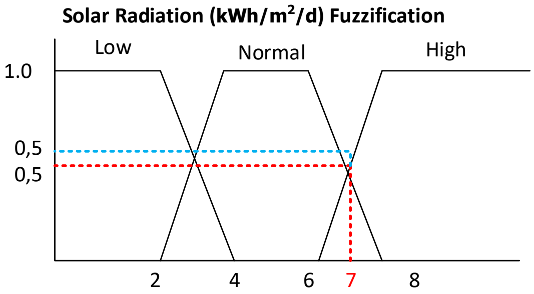
$$\mu_{high}\left[40\left(\frac{m}{s}\right)\right]=\frac{40-30}{45-30}=0,6$$



b. **For the average annual solar radiation is 7 kWh/m^2/d, the membership function describes as follows:**

$$\mu_{low}\left[7\left(\frac{m}{s}\right)\right]=\frac{8-7}{8-6}=0,5$$

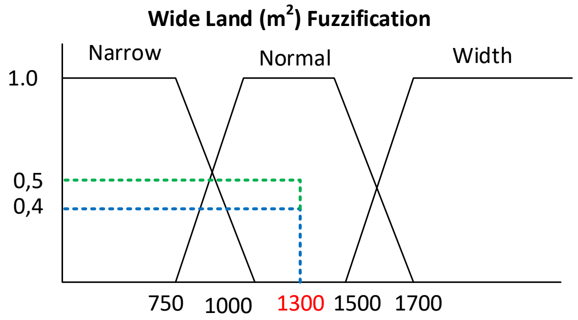
$$\mu_{high}\left[40\left(\frac{m}{s}\right)\right]=\frac{7-6}{8-6}=0,5$$



c. **For the wide of land is 1300 m^2, the membership function describes as follows:**

$$\mu_{low}\left[1300\left(\frac{m}{s}\right)\right]=\frac{1500-1300}{1500-1000}=0,4$$

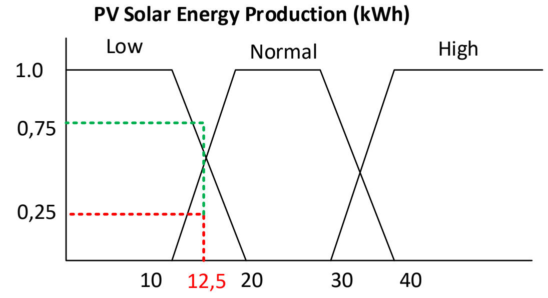
$$\mu_{high}\left[1300\left(\frac{m}{s}\right)\right]=\frac{1300-1000}{1500-1000}=0,5$$



d. **For the PV solar energy production is 12,5 kWh, the membership function describes as follows:**

$$\mu_{low}\left[1300\ (\frac{m}{s})\right] = \frac{20-12,5}{20-10} = 0,75$$

$$\mu_{high}\left[1300\ (\frac{m}{s})\right] = \frac{12,5-10}{20-10} = 0,25$$



5. Rules Of The Proposed Model

Table 3. Rules of the proposed model

Parameters			**PV Production**
Temperature	**Solar Radiation**	**Wide of Land**	
Low	Low	Low	Low
Low	Low	Normal	Low
Low	Low	High	Low
Low	Normal	Low	Low
Low	Normal	Normal	Low
Low	Normal	High	Normal
Low	High	Low	Low
Low	High	Normal	Normal
Low	High	High	Normal
Normal	Low	Low	Low
Normal	Low	Normal	Low
Normal	Low	High	Normal
Normal	Normal	Low	Normal
Normal	Normal	Normal	Normal
Normal	Normal	High	Normal
Normal	High	Low	Normal
Normal	High	Normal	Normal
Normal	High	High	High
High	Low	Low	Low
High	Low	Normal	Normal
High	Low	High	Normal
High	Normal	Low	Normal
High	Normal	Normal	Normal

High	Normal	High	Normal
High	High	Low	Normal
High	High	Normal	High
High	High	High	High

6. Defuzzification

In this works, center of area model of defuzzification is proposed, as equation below:

$$y^* = \frac{\int y\mu_R(y)dy}{\int \mu_R(y)dy}$$

$$y^* = \frac{\sum y\mu_R(y)}{\sum \mu_R(y)}$$

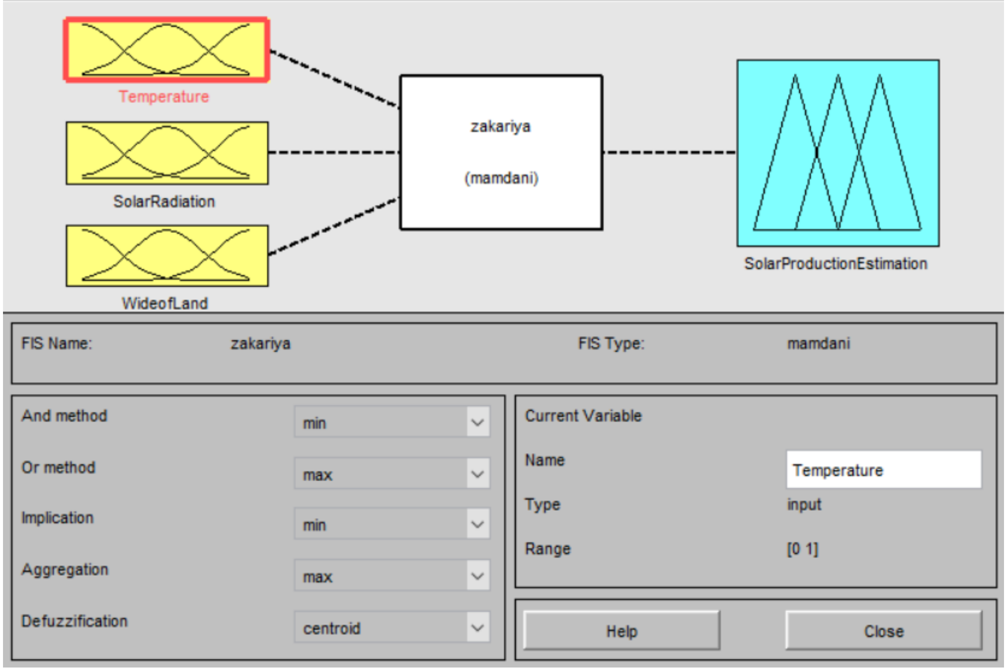
For example, a sample of average annual temperature is 40 °C, so the fuzzification has obtained as 0,6 and 0,3 therefore defuzzification as follows:

$$y^* = \frac{\sum y\mu_R(y)}{\sum \mu_R(y)} = \frac{(45 * 0,6) + (40 * 0,3)}{0,6 + 0,3} = 39$$

Others example of solar production of PV panel is 12,5 kWh has obtained fuzzification are 0,75 and 0,25 therefore defuzzification is

$$y^* = \frac{\sum y\mu_R(y)}{\sum \mu_R(y)} = \frac{(20 * 0,75) + (12,5 * 0,25)}{0,75 + 0,25} = 18,125$$

7. Fuzzy Algorithm Model



FIS Name: zakariya
FIS Type: mamdani

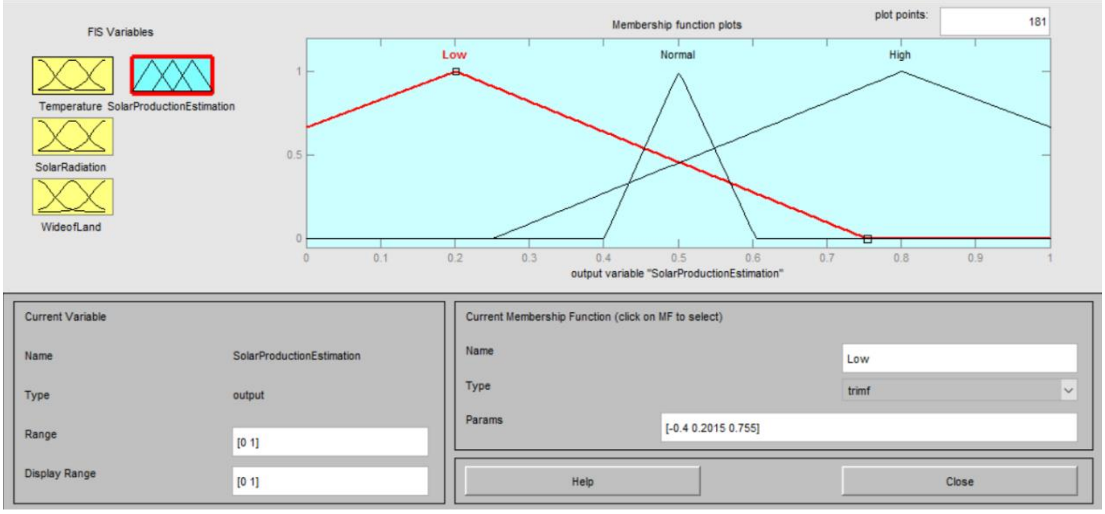
And method: min
Or method: max
Implication: min
Aggregation: max
Defuzzification: centroid

Current Variable
Name: Temperature
Type: input
Range: [0 1]

Figure 5 Proposed fuzzy algorithm of potential solar energy power plant in Libya

Figure 5 has shown 3 parameter input of fuzzy membership function of potential solar energy production in Libya. The parameters such as temperature, solar radiation and wide of lands. Whereas Mamdani algorithm is used for fuzzification of the proposed model. For defuzzification, center of gravity algorithm is used to verify the results of fuzzification process.

8. Results And Analisys



plot points: 181

Current Variable

Name SolarProductionEstimation

Type output

Range [0 1]

Display Range [0 1]

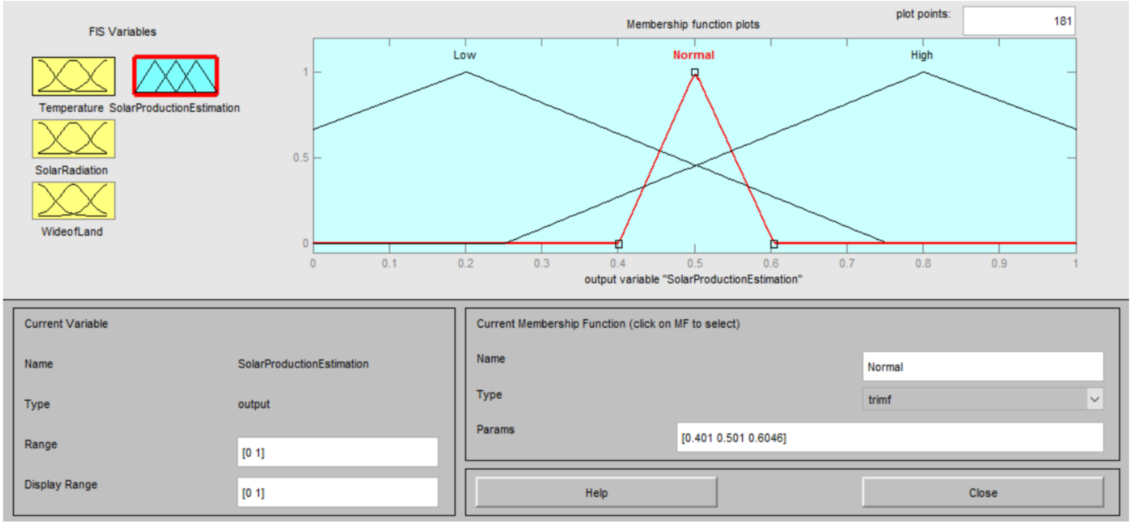
Name Low

Type trimf

Params [-0.4 0.2015 0.755]

Figure 6. Proposed parameter of low state solar energy production for fuzzy algorithm of potential solar energy power plant in Libya

It was shown that fuzzification of the output potential solar energy production in Figure 6 has pointed in values of [-0,4; 0,2; **0,75**] for low state of solar production estimation according to the fuzzification results manually



plot points: 181

Current Variable

Name SolarProductionEstimation

Type output

Range [0 1]

Display Range [0 1]

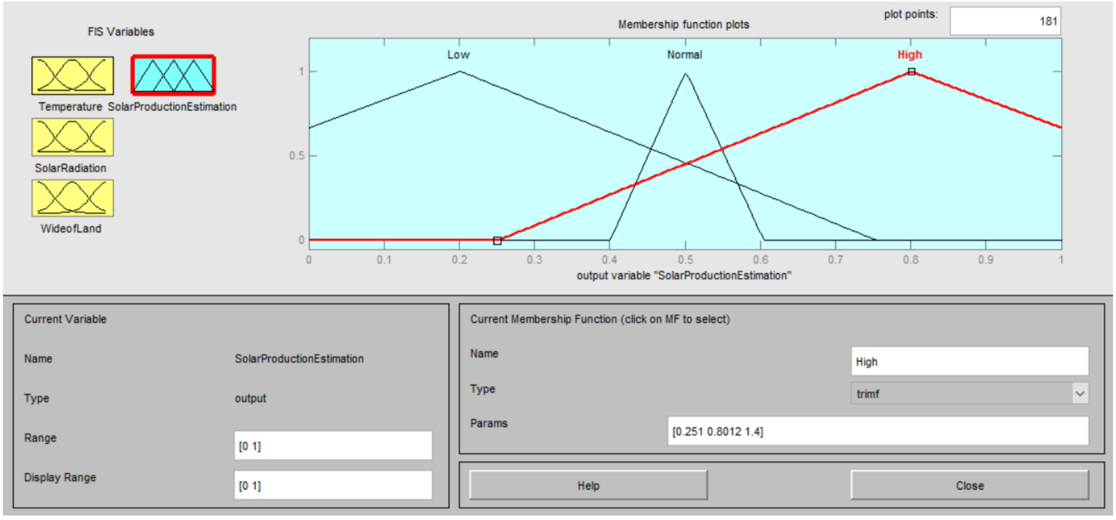
Name Normal

Type trimf

Params [0.401 0.501 0.6046]

Figure 7 Proposed parameter of normal state solar energy production for fuzzy algorithm of potential solar energy power plant in Libya

While for normal state of fuzzification of the output potential solar energy production in Figure 3.7 has pointed in values of [0, 4; 0,5; 0,6] according to the fuzzification results manually.



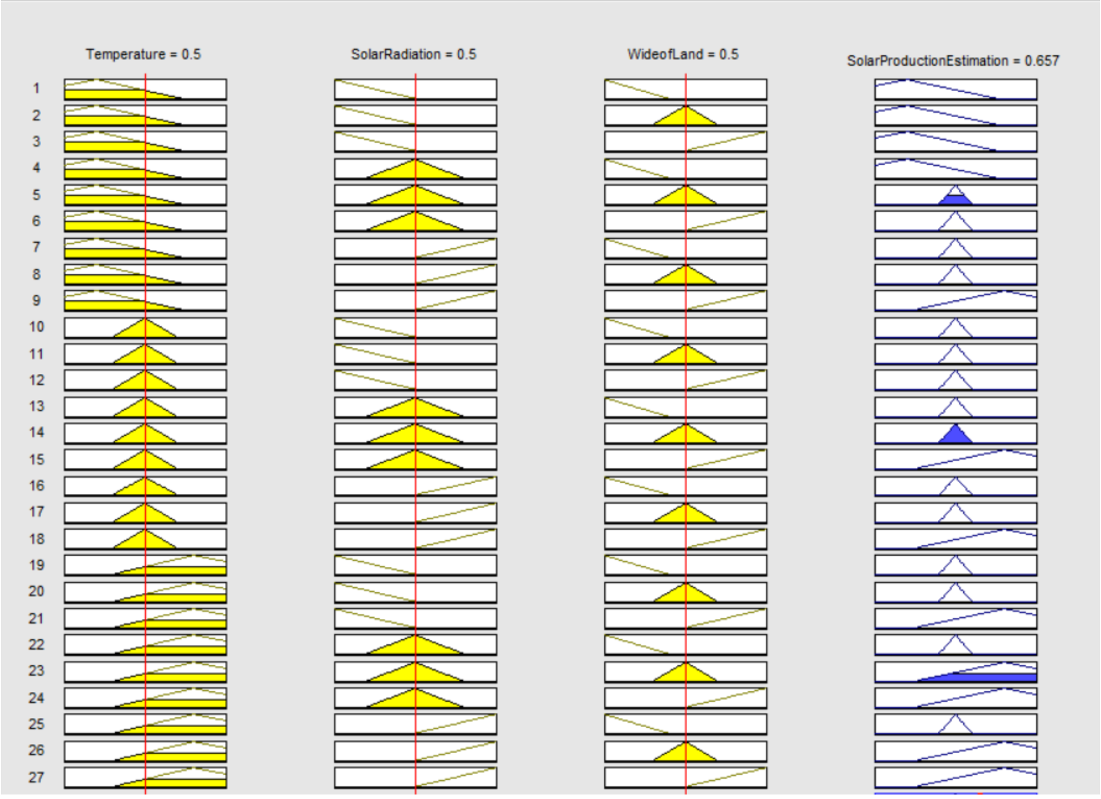
plot points: 181

Current Variable
Name: SolarProductionEstimation
Type: output
Range: [0 1]
Display Range: [0 1]

Current Membership Function (click on MF to select)
Name: High
Type: trimf
Params: [0.251 0.8012 1.4]

Figure 8 Proposed parameter of high state solar energy production for fuzzy algorithm of potential solar energy power plant in Libya

Moreover, high state of fuzzification of the output potential solar energy production in Figure 8 has pointed in values of [0, 25; 0,8; 1,4] according to the fuzzification results manually.



Temperature = 0.5

SolarRadiation = 0.5

WideofLand = 0.5

SolarProductionEstimation = 0.657

Figure 9 Overall performance of solar energy production for fuzzy algorithm of potential solar energy power plant in Libya

Figure 9, has shown the overall performance of potential solar energy production in Libya, as seen in solar production estimation, a value has pointed more than >0,5 means that by applying fuzzy algorithm could improve solar production of energy. Therefore, the potential of the solar energy power plant in Libya possible to deployed.

Table 4. The performance Fulfill Demands of the Solar Energy Production without Fuzzy Algorithm

Fullfil Energy Demands (kWh/)	Months	Clearness Index	Daily Radiation (kWh/m^2/d)	(A) Total solar panel Area (m^2)	(H) Annual average irradiation on tilted panels	(PR) Performance ratio, coefficient for losses (%) (between 0.5 to 0.75)	(r) Solar Panel Yields (%)	Total power of the system (kWp)	Number of Module without Fuzzy
1546.88	January	0.64	4.34	1000	6.1875	0.5	50%	500	45.80
2041.88	February	0.66	5.56	1100	6.1875	0.6	50%	550	60.45
2598.75	March	0.64	5.89	1200	6.1875	0.7	50%	600	76.94
3217.50	April	0.64	6.01	1300	6.1875	0.8	50%	650	95.25
3898.13	May	0.67	7.38	1400	6.1875	0.9	50%	700	115.41
3480.47	June	0.67	8.21	1500	6.1875	0.75	50%	750	103.04
3712.50	July	0.69	8.05	1600	6.1875	0.75	50%	800	109.91
3944.53	August	0.69	7.96	1700	6.1875	0.75	50%	850	116.78
4176.56	September	0.67	6.25	1800	6.1875	0.75	50%	900	123.65
4408.59	October	0.66	5.89	1900	6.1875	0.75	50%	950	130.52
4640.63	November	0.68	4.54	2000	6.1875	0.75	50%	1000	137.39
4872.66	December	0.69	4.17	2100	6.1875	0.75	50%	1050	144.26

As shown in Table 4, the demands energy could be fulfilled by using power production equation based on clearness index which found first the mean value to determine solar panel yields. Therefore, the production is depending on total solar panel area which are desired. For example, clearness index is 0,64 in January, total area solar panel is 1000 m2 with average irradiation is 6,1875, performance ratio is 0,5 and solar panel yield is 50% can produce 1546,88 kWh and need 46 PV module should be installed.

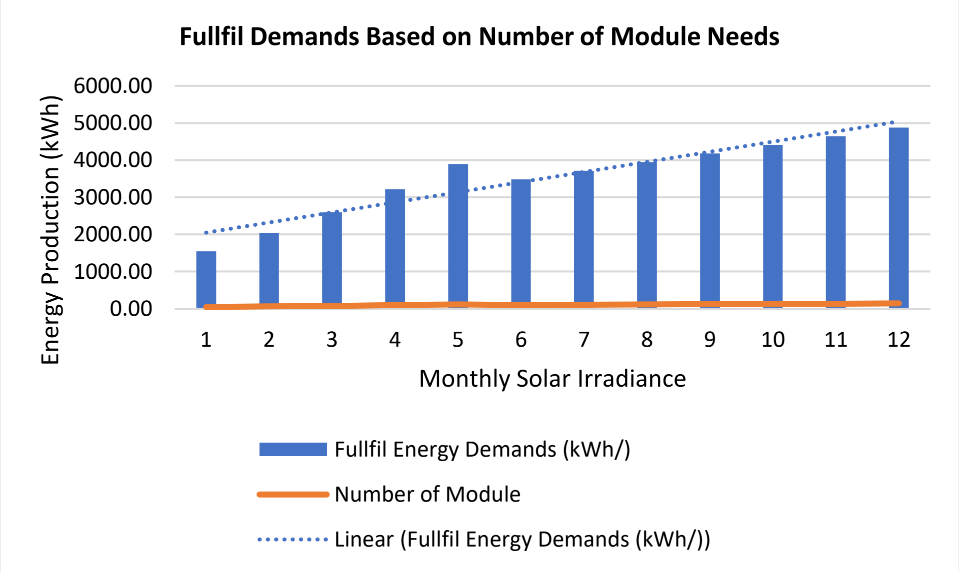


Figure 10. Overall Performance of fulfill energy demands based on number of PV Module Needs

It could be verified in Figure 10, the performance of fulfill energy demand based on clearness index shows the potential number of solar energy production could be performing well. Number of module increased inline of solar energy demands, and could reduce by expanded wide of lands areas.

Table 5. The performance Fulfill Demands of the Solar Energy Production using Fuzzy Algorithm

Fullfil Energy Demands (kWh) based on Fuzzy	Months	fuzzy Clearness Index	Daily Radiation (kWh/m^2/d)	z	from Normal Distribution	Probability	(A) Total solar panel Area (m^2)	(H) Annual average irradiation on tilted panels	(PR) Performance ratio, coefficient for losses (%) (between 0.5 to 0.75)	(r) Solar Panel Yields (%)	Total power of the system (kWp)	Number of Module using Fuzzy
125.02	January	0.32	2.17	0.005081671	0.496	49.6	1000	3.09375	0.5	52%	519.9	32.12
421.41	February	0.33	2.78	0.015081671	0.504	50.4	1100	3.09375	0.5	52%	571.89	41.15
164.83	March	0.32	2.945	0.005081671	0.5199	51.99	1200	3.09375	0.5	52%	623.88	43.59
178.56	April	0.32	3.005	0.005081671	0.5199	51.99	1300	3.09375	0.5	52%	675.87	44.48
725.53	May	0.335	3.69	0.020081671	0.508	50.8	1400	3.09375	0.5	52%	727.86	54.62
777.35	June	0.335	4.105	0.020081671	0.508	50.8	1500	3.09375	0.5	52%	779.85	60.76
1261.72	July	0.345	4.025	0.030081671	0.512	51.2	1600	3.09375	0.5	52%	831.84	59.58
1340.57	August	0.345	3.98	0.030081671	0.512	51.2	1700	3.09375	0.5	52%	883.83	58.91
932.82	September	0.335	3.125	0.020081671	0.508	50.8	1800	3.09375	0.5	52%	935.82	46.26
727.89	October	0.33	2.945	0.015081671	0.504	50.4	1900	3.09375	0.5	52%	987.81	43.59
1294.54	November	0.34	2.27	0.025081671	0.508	50.8	2000	3.09375	0.5	52%	1039.8	33.60
1656.00	December	0.345	2.085	0.030081671	0.512	51.2	2100	3.09375	0.5	52%	1091.79	30.86

As shown in Table 5, the demands energy could be fulfilled by using power production equation based on clearness index which found first the mean value to determine solar panel yields. In this terms, clearness index is applied of fuzzy algorithm in order to perform the impact of solar energy production based Therefore, the production is depending on total solar panel area which are desired for produced. In this works, solar panel yields have been explorer by calculated of standard deviation based on normal distribution and yield of 53%. For example, clearness index is 0,335 in September, total area solar panel is 1800 m^2 with average irradiation is 3,09375, performance ratio is 0,5 and solar panel yield is 52% can produce 932,82 kWh and need 46 PV module should be installed.

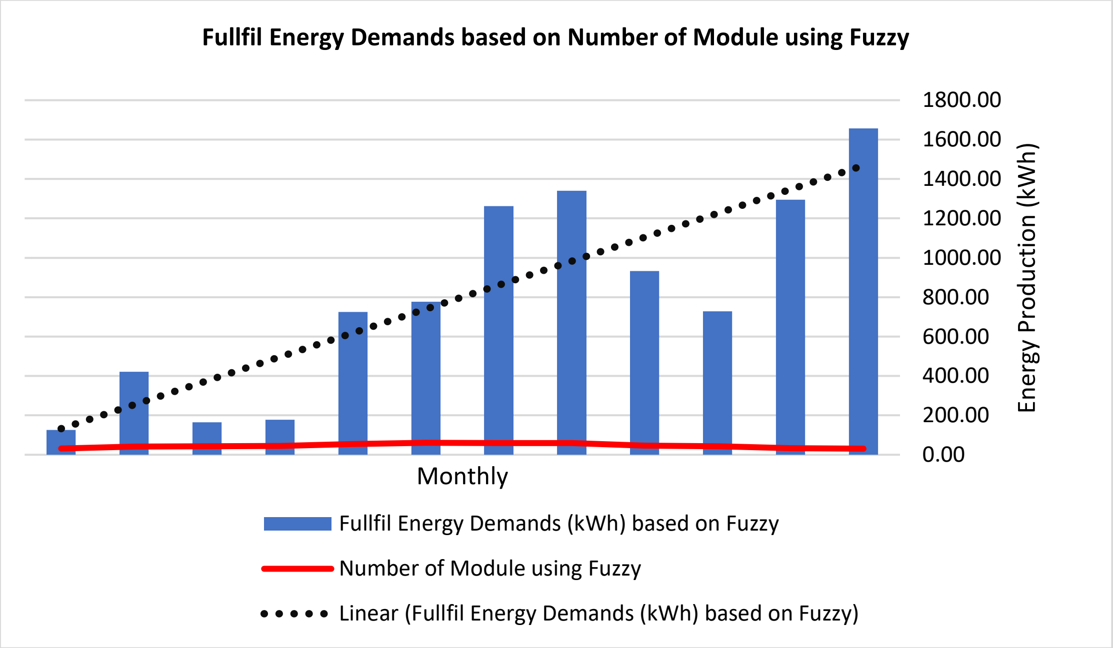


Figure 11. Overall Performance of fulfill energy demands based on number of PV Module Needs using fuzzy algorithm

It could be verified in Figure 11, the performance of fulfill energy demand based on clearness index shows the potential number of solar energy production could be performing well. Number of module increased inline of solar energy demands, and could reduce by expanded wide of lands areas. As compared to the performance without fuzzy, a proposed fuzzy algorithm by using lowest clearness index could perform solar energy production as well as approached the results with conventional production.

9. Conclusion

It's verified that the performance of potential solar energy production based on clearness index, wide of land and temperature using fuzzy algorithm has been performed well. A proposed algorithm has shown that lowest clearness index of solar irradiance could be perform well to combat low energy production during low absorption of PV panels. In future, neuro fuzzy algorithm could have deployed in order to improve solar energy production in lower solar irradiance conditions.

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