PV System Output Analysis of Special Weather Affect

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Abstract

The PV system output changes with environment，and showing impact of a stochastic volatility to PV grid-connected power generation，so study the characteristics of PV system under the influence of environmental factors to improve operational management of photovoltaic power plants connected to the grid level of significance．By collecting the data on the PV output characteristics of various weather data analysis, and explore the role of the surface of the ash deposition. The effects of various environmental factors and ash on the output of photovoltaic cells were obtained. The results show that the irradiance has the greatest influence on the output, the temperature and humidity are the second, and the humidity can be ignored; Fog and haze and low temperature make ash accumulation have a greater impact on the output.

Keywords

PV systems, output characteristics, smog, ash accumulation.

1. Introduction

Today fossil fuels are drying up, The greenhouse effect is getting worse day by day, the development of clean energy has become imminent. Our country is vast, and solar energy resources are better. National "12th Five-Year" plan vigorously promote solar photovoltaic power generation, photovoltaic power generation systems are evolving from stand-alone systems to large-scale grid connected systems. The output of photovoltaic system changes regularly with temperature, weather, season and time, which will cause periodic impact on power grid. Therefore, the analysis of the output characteristics of photovoltaic systems from different environmental factors is of great significance for the design, operation and maintenance of photovoltaic systems and the determination of the accurate model of power prediction.

Because of the uneven distribution of solar energy resources, the uneven intensity of light and environment, and the randomness, fluctuation, periodicity, intermittence and so on, many domestic scholars have carried on the related research [1-3]. Therefore, it is of important theoretical and practical value to study the comprehensive output characteristics of photovoltaic power plants [4].

In recent years, the construction of large and medium-sized photovoltaic power plants has increased, but the impact of environmental factors on their output characteristics has been relatively few in the actual operation of photovoltaic power plants, according to the actual situation of Baoding area, the output of the experimental data acquisition data and haze weather day when, and in the same kind of weather conditions of photovoltaic panels dust on the surface area of the experimental data, the data analysis is carried out by MATLAB, by comparison, the output characteristics of photovoltaic panels under different weather conditions and the influence of surface area on the output of photovoltaic panels are investigated.

2. Overview of Photovoltaic Power Generation

In recent years, Hebei has been a major province of photovoltaic power plant construction. With the better lighting resources, high-quality land and better subsidy policies, the PV installed capacity is increasing every year. Figure 1 shows the trend of PV installed capacity in Hebei in recent years, the

installed capacity has increased year by year, it can be seen that photovoltaic power generation will have more room for development in the future.

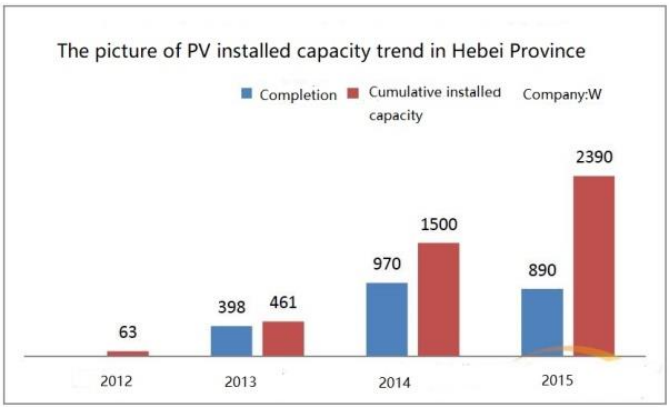

Figure 1 PV installed capacity over the years

It is reported that Baoding or will receive more government funding, poverty alleviation projects will become a new model for many investors to develop and build photovoltaic power plants.

However, due to the special weather in Baoding, in autumn and winter, fog and haze weather is more serious, therefore, the study of fog and weather, volt battery output characteristics of the future development of photovoltaic projects in Baoding has a certain significance.

3. Experimental Design

3.1 Experimental Site

The experiment site was selected from the two campus of North China Electric Power University in Hebei, Baoding province. The data were collected from the middle of December to the middle of January and the first three weeks of March. After collecting the data, select the valid data, and compare the 10 groups of 10 groups of fog and haze in sunny days. This area from December to January, mainly for fog and haze, solar radiation is relatively small, March mainly sunny weather, relatively large amount of solar radiation.

Figure 2 Experimental equipment

3.2 Experiment Procedure and Process

The boards were measured every day, the first group of boards were cleaned once a day, second groups of boards clean up once in three days, and third groups of boards clean up once every seven days, the characteristics of photovoltaic power output under special weather conditions are studied, and the influence of surface area ash on the output is also studied by using the collected output data.

4. Analysis of Output Characteristics of Photovoltaic Panels

The output characteristics of photovoltaic power generation are determined by the characteristics of light resources and the characteristics of power generation equipment. Due to the influence of light, the output of photovoltaic power plants is different in sunny and rainy days.

4.1 Photovoltaic Output in Clear Weather

In this paper, the output of photovoltaic panels under the condition of lower air pollution index (AQI) is observed under better weather conditions.

At that time, most of the weather was shown in Figure 3. We had a data acquisition at noon every day, using a voltmeter, ammeter, and 40 power load resistors to form a simple resistor circuit, the experiments were conducted for three weeks, and ten days of typical experimental procedures were performed for data processing. The experimental circuit is shown in figure 4.

Figure 3 Sunny weather

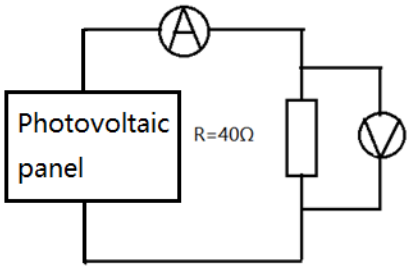

Fig. 4 Experimental circuit diagram

Table 1 Experimental data of clear days

	1	2	3	4	5
Humidity /%RH	68	95	95	97	96
T/℃	5	7	11	13	14
Irradiance /J*m-2	382.4	357.4	392.3	372.8	378.2
Power/W	10.33	11.05	10.95	10.99	10.39

	6	7	8	9	10
Humidity /%RH	96	85	73	84	97
T/℃	16	15	9	11	16
Irradiance /J*m-2	342.6	332.8	394.6	368.4	365.4
Power/W	10.26	10.07	10.59	10.86	10.34

Fitting curves by data can be used to obtain the fitting results.

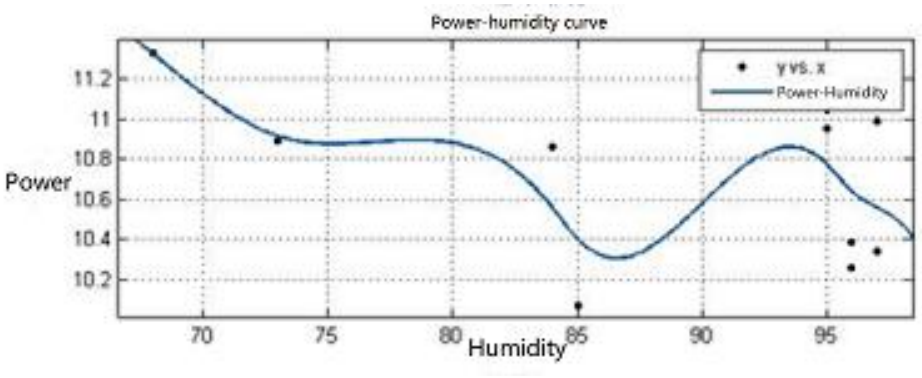

Figure 5 Power-humidity curve

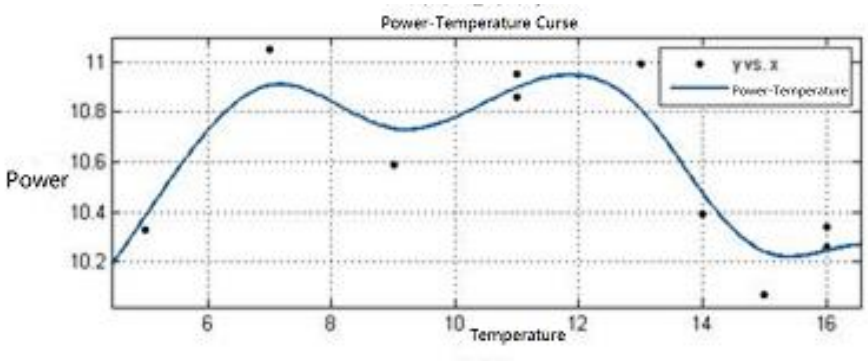

Figure 6 Power-temperature curve

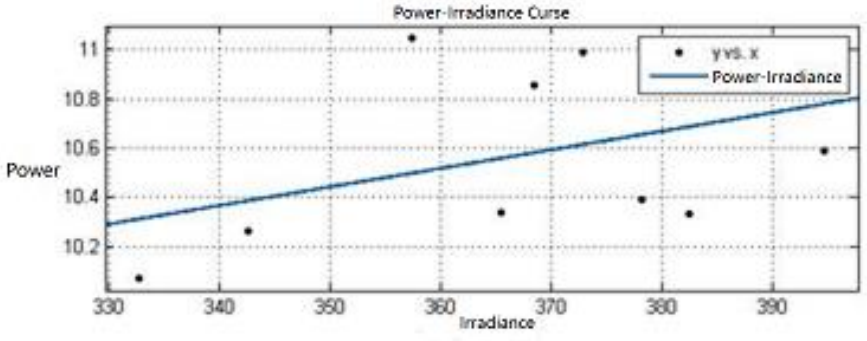

Fig. 7 Power-irradiance curve

As can be seen from Figure 5 and Figure 6, the influence of temperature and humidity on power is not monotonic, but has a certain fluctuation, moreover, the influence of the two on power is lagging behind. It is a positive correlation before the temperature reaches a certain value, and when the temperature exceeds a certain value, the increase in temperature will suppress the increase in the output power of the photovoltaic system. The influence of humidity on power is the opposite of temperature.

From Figure 7, the data of irradiance and power are fitted by linear regression. The curve shows obvious monotonic upward trend. It is known that irradiance has great influence on power, and both of them have higher positive correlation.

4.2 Haze Days of Photovoltaic Output

During the winter, from January December to January 1, the experimental data were collected for one month, and the effective data were screened for data analysis.

Table 2 Experimental data haze days

	1	2	3	4	5
AQI	260	371	260	215	191
T/℃	0	-4	-4	-1	-2
Irradiance /J*m-2	189.8	203.5	67.2	405.7	248.9
Power/W	10.33	11.05	10.95	10.99	10.39
	6	7	8	9	10
AQI	225	333	235	194	107
T/℃	-1	2	3	2	0
Irradiance /J*m-2	342.6	332.8	394.6	368.4	365.4
Power /W	10.26	10.07	10.59	10.86	10.34

Using MATLAB software for data fitting, you can get curves.

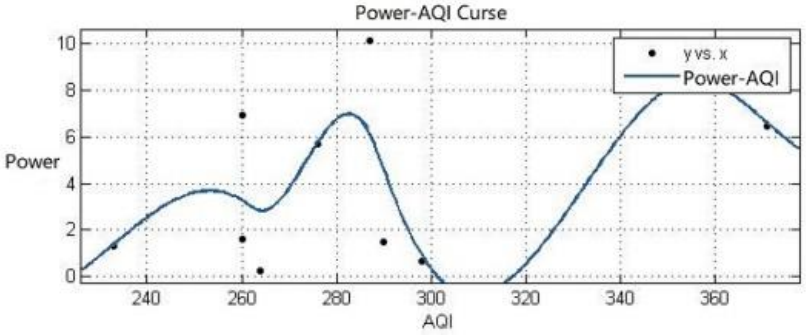

Fig. 8 Power -AQI curve

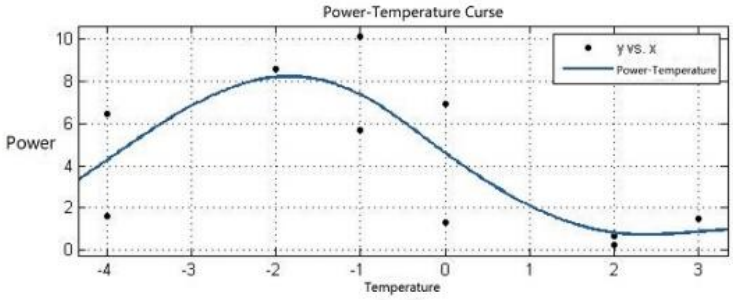

Figure 9 Power-temperature curve

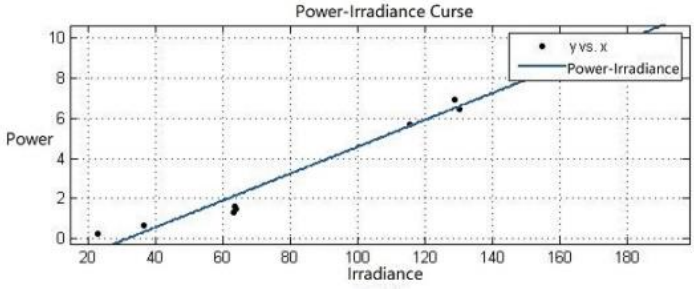

Fig. 10 Power-irradiance curve

As can be seen from figure 8, the influence of AQI on power is not obvious, the curve shows multi peak characteristics, and the whole is not stable and fluctuates greatly. Therefore, all kinds of pollutants in AQI have no monotonic influence on the PV output, and the law of their effects is not easy to study, and AQI mainly affects the output of photovoltaic panels by blocking light and decreasing irradiance.

As can be seen from Figure 9, the influence of temperature on power is somewhat delayed. Although the curve is slightly fluctuating, it shows a negative correlation as a whole. The higher the temperature is, the smaller the power is.

As can be seen from Figure 10, irradiance has the greatest influence on power, and the curves obtained by linear regression show obvious monotonicity. The greater the irradiance, the greater the power, the two have obvious positive correlation.

This section mainly analyzes the influencing factors of the environment and sunny haze weather on output panels, a curve fitting results, the most obvious influence on the output irradiance, showed significant positive correlation; effect of temperature on the battery plate output is weaker than the irradiance, the sunny day, the nature of the fitting curve has multiple peaks. Haze weather, although the fitting curve fluctuated slightly, but the overall negative correlation, the higher the temperature, the output would be smaller; Effect of humidity on power, showed a negative correlation on the whole, but also in a certain area (90%-95%) showed positive correlation, humidity - power curve is relatively flat, the output is less than the effect of humidity on temperature and irradiance; The effect of AQI on the output of the fitting curve is not easy, no obvious regularity, multi peak and unstable, the main function of AQI is, by the amount of radiation absorbed pollutant output occlusion sunlight to weaken the photovoltaic panels.

5. Effect of Ash Deposition On The Output of Photovoltaic Panels

Solar photovoltaic system in the operation process, will be affected by their environment of dust, on the photoelectric conversion efficiency of photovoltaic panels and solar radiation intensity, dust accumulated in the photovoltaic panel surface, will make the glass surface decreased, decreased transmittance of the output performance of the battery plate decreases, the greater the concentration of deposition the light transmission rate is low, the amount of radiation, the surface absorption is low, the output performance decreased, will bring a great waste of energy. It is easy to cause the thermal spot effect, which leads to the decline of solar cell performance[7-8], and seriously affects the output power and conversion efficiency of solar cells[9].

5.1 Influence of ash deposition on photovoltaic output in clear weather

The test site is located at the campus in school. A photovoltaic panel is placed in an open space, and the battery board is cleaned every day with clean water.

In the test site, we prepared two boards, which were cleaned once a day, cleaned once every seven days, recorded their power data, analyzed and compared.

Data were analyzed using 2.22-3.7 valid data for fourteen days (two cycles).

Table 3 Experimental data of clear days

	1	2	3	4
Cleaned	10.32	11.05	10.95	10.99
Not cleaned	10.32	10.69	10.37	10.44
	5	6	7	
Cleaned	10.39	10.26	10.07	
Not cleaned	9.94	9.95	9.72	
	8	9	10	11
Cleaned	10.59	10.86	10.34	10.44
Not cleaned	10.58	10.45	9.91	9.73
	12	13	14	
Cleaned	10.69	10.45	10.87	
Not cleaned	10.17	9.94	10.31	

The curves of the following two cycles are obtained by fitting the experimental data.

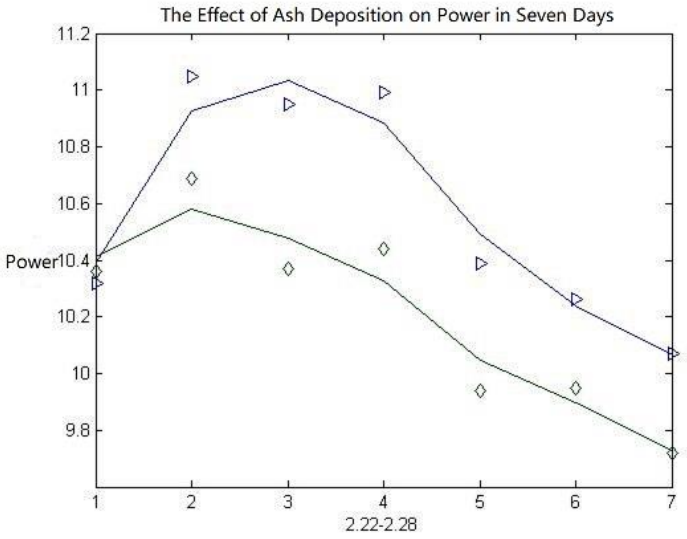

Fig. 11 Power change in clear weather

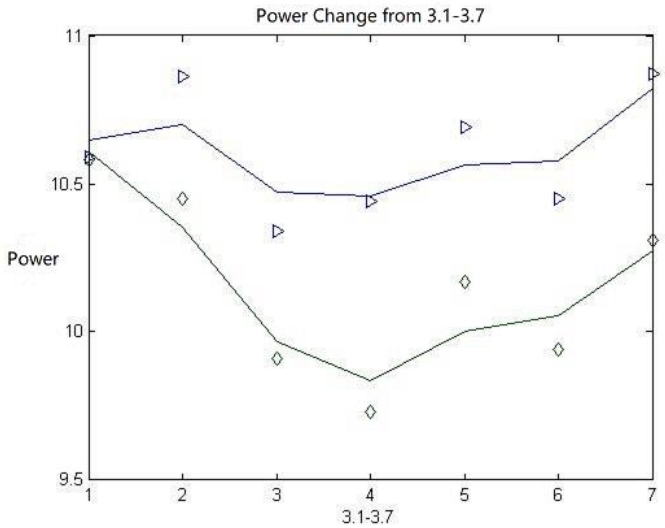

Fig. 12 Power change in clear weather

Figure two shows a sunny day in a week when the panels output by the ash, purple line is all panels cleaning every day, the green line is not panels cleaning, for a period of seven days, the two panels of the output change fitting to a coordinate system.

Daily power down rate can be calculated

$$\alpha\% = \frac{W_0 - W}{W_0} \times 100\% \quad (1)$$

Formula

α%———Daily power down rate W_0———Power of photovoltaic panels without ash deposition

W———The power of a photovoltaic cell board

By calculation, the daily power drop rate in the first cycle is followed by:

0.0%,3.78%,4.16%,4.87%,4.98%,4.88%,5.15%， the rate of decline began to increase gradually, and then basically stabilized at about 5%.

Calculated by the same method, the daily rate of power decrease in the second cycles is followed by:

0.0%,3.26%,5.30%,5.04%,4.33%,5.02%,4.68%, the rate of decline began to increase, then decreased slightly, and the value of alpha was also about 5%.

Data analysis shows that when the base of the original power is relatively large, the rate of decline is relatively low, and when the base number is relatively small, the rate of decline will be higher; When

the temperature is relatively high, the rate of decline is relatively low. When the temperature is relatively low, the rate of decline is higher, and the ash deposition has a certain relationship between the decline rate of power and temperature.

5.2 Influence of ash accumulation on power during fog and haze

The test time is from early December to early August, the haze is more serious, the effective 12.30-1.8 data were analyzed for two weeks.

Table 4 Experimental data haze days

	1	2	3	4
Cleaned	10.455	10.18	9.31	9.39
Not cleaned	10.455	9.30	8.83	8.81
	5	6	7	
Cleaned	6.91	6.48	1.62	
Not cleaned	5.21	5.52	1.44	
	8	9	10	11
Cleaned	10.13	8.61	5.7	0.24
Not cleaned	10.13	8.28	5.29	0.16
	12	13	14	
Cleaned	1.46	0.64	1.32	
Not cleaned	1.44	0.63	1.29	

The experimental data are fitted by curve, and the graph can be obtained as follows.

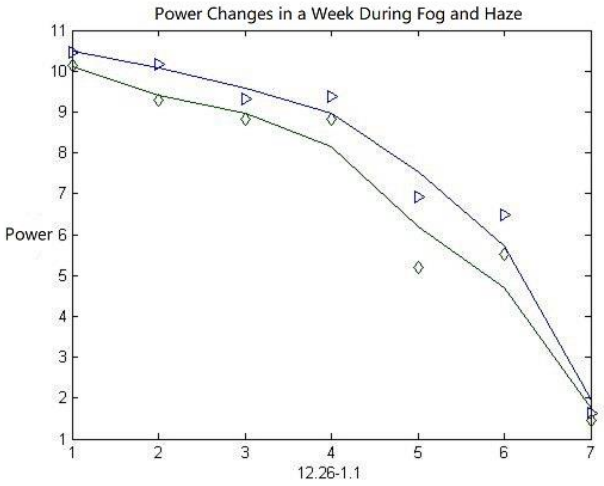

Figure 13 Power changes in haze days

A graph of the second cycle.

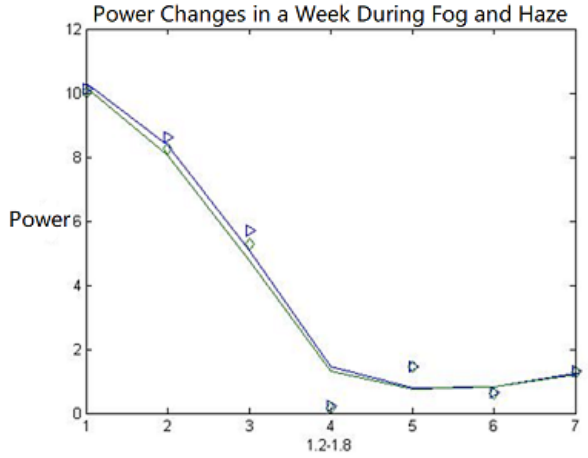

Figure 14 Power changes in haze days

Figure two shows the haze days within a week by the ash panels output effect, purple lines represent every day cleaning panels, the green line is not battery plate cleaning, for a period of seven days, the two panels of the output change fitting to a coordinate system.

Into the formula calculation, in the first cycle, the daily power drop rate α% is sequentially as follows:

0% 8.64% 5.15 % 6.18% 24.6% 14.8% 11.1%.

Within second cycles, the daily power drop rate, alpha, and percent are in turn:

0% 3.38% 8.42% 33.3% 13.7% 21.2% 11.8%

Comparing this data with the previous one, we can see that the influence of ash accumulation on output is different in different weather. The most direct influence of fog and haze is irradiance, so as to get the conclusion: the ash surface photovoltaic panels will make the power of the battery plate decreases daily power drop rate was also related to environmental factors. When the irradiance is lower, the greater the decrease rate of power is, the greater the irradiance is, the decrease rate of power will decrease; when the temperature is higher, the lower the power drop rate, the lower the temperature, the higher the rate of power decline.

6. Conclusion

According to the analysis of this paper, it can be found that the output characteristics of photovoltaic system are greatly affected by various environmental factors, which are mainly affected by solar irradiance and temperature. According to the meteorological data under different weather conditions, using MATLAB data analysis, it can predict the output of photovoltaic system, and thus play a positive role in power grid scheduling, and used in practice. Using the output characteristics of photovoltaic system under different typical days as a reference, the temperature range of the battery board can be roughly judged, thermal damage can be prevented, and the photovoltaic system can be judged in real time.

Dust accumulated on the surface of packaging materials can make the surface of the transparent photovoltaic modules, photovoltaic components decreased, decreased transmittance will lead to a decline in the output performance of the module, and the accumulated dust concentration is higher, the greater the decline in output performance of components. This paper also explores the influence of ash accumulation on the output in fog and haze, and compares it with the clear weather, and gets the influence of environmental factors on the rate of power decline in the same ash deposition.

For a single component, the output power decreased, but composed of tens of thousands of pieces of large, oversize grid connected photovoltaic system, the total output of the decline will be very large, the power loss caused by the annual will be great. Regular cleaning, maintenance and repair of the battery board can prolong the service life of the battery board, stabilize the output power of the photovoltaic system and improve the efficiency of the photovoltaic system.

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