

# Role of Green Energy in Sustainable Development in Rajasthan

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**Abstract:** Exponential growth in population, economic growth, rapid Industrialization to become a developed Nation, increasing domestic demand of energy and drying up of conventional sources of energy has led us to look for an alternative source of energy. Till date the main source of energy required for growth and development is coal, which is exhaustible, non renewable as well as harmful for the environment. Hence, we are forced by changing environment to move towards green energy which is the solution to the emerging problem of exhausting conventional energy sources and increased carbon footprints. It is environment friendly too for human race to pass on to next generation for continued development. Renewable energy is also called "Green Energy" or "Clean Energy" because it does not pollute the environment. As we all are aware that energy can neither be created nor be destroyed rather it transforms from one form to another. Green energy includes solar energy, wind energy, biogas energy etc which are already existing in different form in environment. Rajasthan is endowed with abundant green energy potential to transform it in form useful for the state growth and development. However, there is scarcity of carbon sources in state. Many developed countries are behind India in harnessing the potential of green energy for sustainable development. Rajasthan, ranked first with 19% share of installed renewable energy capacity in India. This paper provides a brief overview of the availability and current status of renewable energy in Rajasthan and its role in sustainable development of state which is taking Rajasthan from energy deficit state to energy surplus state among other states of our country. It will also help the researchers and investors to explore the vast possibility of implementation of modern technology to harness abundant green energy and to map out for the expansion of green energy generation at faster pace to reduce the carbon foot print and coal dependency.

**Keywords:** Green energy, Conventional energy, Solar energy, Wind energy, Biogas energy, Sustainable development, Carbon footprint etc.

## 1. Introduction

Globally energy consumption is increasing phenomenally due to exponential growth in population, rapid industrialization, growing economy, urbanization, increasing domestic demand of energy and so on. The rise in the energy consumption and its consequences in recent years is so frightening. Hence, we are forced to look for alternative source of energy. Green energy which is also known as "Clean Energy" or "Renewable Energy" is attracting focus of each and every country in the world.

Today the world's attention has shifted to environmental concern as a result of global warming, melting of ice, the excess of greenhouse gasses and other extreme climatic changes. Looking towards global environmental problems various countries around the world came together with climate negotiation under the United Nations framework convention on climate change. India is an active participant of this noble drive and committed to generate clean, green and carbon footprint free energy in environment friendly manner. Many developed countries are behind India in harnessing the potential of green energy for sustainable development. India's commitment towards making policies to achieve environmental goals and to mitigate the impact of climate change is also acknowledged by the World. India target is to achieve the 50% production of energy through renewable energy sources by 2030. India has the fourth largest amount of renewable energy capacity with 176 GW after China (1453 GW), US (388 GW) and Brazil (194 GW) in 2023. China produced 31% of global renewable electricity followed by the United States with 11%, Brazil with 6.4% and India with 3.9%.

The total capacity of thermal power plants was 2, 31, 870.72 MW as on January 31, 2021 which generates 71% of the total power generation in India, responsible for increased carbon emissions and other hazardous gasses. To combat against carbon emission, India is switching towards renewable energy or green energy. Renewable energy generation rises from 17.28% in 2014 - 15 to 21.67% in 2020 - 21. The energy which does not pollute the environment and replenish naturally is called green energy. The energy sources such as sunlight, wind, biogas, geothermal etc can be called green energy sources, as these are eco - friendly and renewable.

Cumulative installed renewable energy capacity excluding large hydro power was 35, 849.59 till 2014. In later years the capacity was 7, 141.3 MW (2015 - 16), 12, 093.24 MW (2017 - 18), 8, 84 3.31 MW (2019 - 20), 14, 081.97 MW (2021 - 22) and 18, 484.68 (2023 - 24). Cumulative achievement in installed renewable energy capacity became 1, 52, 654.48 till date August 31<sup>st</sup> 2024.

### Cumulative Achievement in Installed Renewable Energy Capacity

S No	Source	As on 31 - 03 - 2014 (MW)	As on 31 - 08 - 2024 (MW)
1	Wind Power	21042.58	47192.33
2	Solar Power	2821.91	89431.98
3	Small Hydro Power	3803.68	5070.75
4	Biomass Power (Bagasse)	7419.23	9433.56
5	Biomass Power (Non - bagasse)	531.92	921.79
6	Waste to Power	90.58	249.74
7	Waste to Energy (Off Grid)	139.79	354.33
8	TOTAL	35849.59	152654.98

Source: Ministry of New and Renewable Energy, Government of India

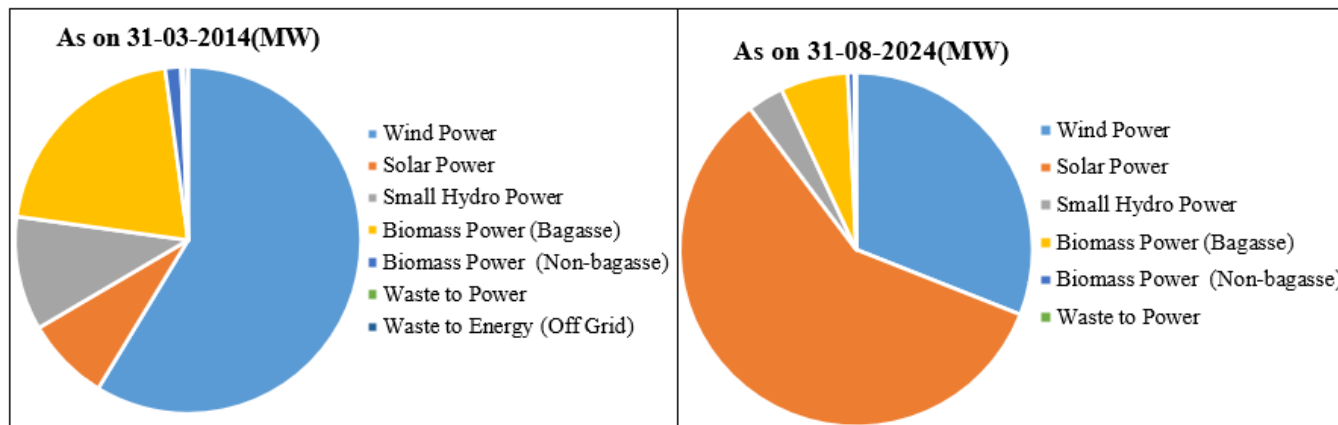
Volume 13 Issue 10, October 2024

Fully Refereed | Open Access | Double Blind Peer Reviewed Journal

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Rajasthan ranked first with 19% share of installed renewable energy capacity in India. Gujarat contributes more than 16% in installed renewable energy capacity in India. Gujarat is also leading in rooftop solar energy. Gujarat stands at first rank in tapping wind energy in country. Rajasthan ranks first with 26,

692.89 MW installed renewable capacity followed by Gujarat with 25, 471.72 MW, Tamilnadu with 19, 983.42 MW, Karnataka with 17, 752.74 MW, Maharashtra with 14, 483.12 MW capacity as on 31<sup>st</sup> March 2024 (State wise cumulative installed capacity, MNRE).



### Achievement in Installed Renewable Energy Capacity

*Pradhanmantri Surya Ghar Muft Bijali Yojana*: It is an initiative aimed at promoting the adoption of solar energy across the nation. it was introduced on 22 January 2024. This scheme is a step towards sustainable energy as well as a leap towards a greener future. It is designed to transform the energy industry by developing solar panels on the rooftops of houses belonging to middle class and lower - class income citizens nationwide. With a vision to light up one crore homes using solar power, this scheme is pivotal in India's journey towards energy self - sufficiency and meeting the ambitious net zero target. MNRE is the overall program implementation agency for the rooftop solar scheme. Gujarat is at rank one in highest installed capacity with 4027.71 MW followed by Maharashtra with 2379.16MW and Rajasthan with 1258.15MW.

### Study Area

Rajasthan the largest state of India and home to the great Indian desert which lies between 23°3' to 30°11' minutes North latitude and 69° 29' to 78° 17' East longitudes. It covers an area of 3.42 lakh square kilometre which is 10.41% of the total geographical area of India. The Thar desert covers 2.08 lakh square kilometre area which is 61.1% of the total geographical area of Rajasthan. It is characterized by arid and semi - arid climatic conditions, Sandy terrain, 300 to 330 sunny days, large barren land etc. Jaisalmer, Jodhpur, Barmer, Bikaner, Churu, Sikar, Hanumangarh etc. are the main district covered by Thar desert. The current estimated population of Rajasthan is approx 8.36 crores. Chambal, Luni, Banas are the main rivers and Chambal is the only perennial river among them. In summer season the temperature remains in range of 33°C to 46°C.

### Objectives

- 1) To assess the current status and extent of green energy potential in Rajasthan.
- 2) To understand how the Western Rajasthan is working towards development of green energy and facing the challenges ahead.

- 3) To analyse the utility of green energy sources in mitigating the climate change and other environmental problem.
- 4) To understand the need to switch on to green energy from conventional energy.

### Hypothesis

- 1) Null hypothesis: There is no impact of green energy in sustainable development in Rajasthan.
- 2) Alternative hypothesis: Green energy generation in Rajasthan is having significant impact on achieving sustainable development in state.

### Data Source

The study is based on secondary data which are collected from online site of the Ministry of New and renewable energy department, Government of India. Some data also taken from newspaper article in Rajasthan Patrika.

### Green Energy in Rajasthan

On one hand Rajasthan faces a number of challenges with conventional energy as low available of perennial rivers limits its ability to generate hydroelectricity and for thermal energy production the state needs to transport coal from other states which contributes to 50% of the cost of energy production. Conventional energy resources like coal, oil, petroleum are exhaustible and pollute the environment by emitting carbon gasses and so on which results in various environmental problems like climate change, global warming, melting of ice, etc. On the other hand, Rajasthan has abundant potential for renewable energy. Globally many countries are searching and shifting on renewable energy from conventional energy as fossil fuel - based energy is diminishing rapidly and it is responsible for many environmental problems too. Rajasthan has the leading role in expanding India's renewable Power capacity and transferring the electricity grid to a cost effective, inexpensive and environmentally friendly electricity system. The climatic condition makes it perfect for capturing the solar rays efficiently. There is appropriate condition to receive nearly 300 to 330 sunny days a year and 5 to 7 kwh per square metres sun radiation per day. High radiation, wind speed and convenience of huge barren land

are appropriate for solar and wind energy generation in Rajasthan.

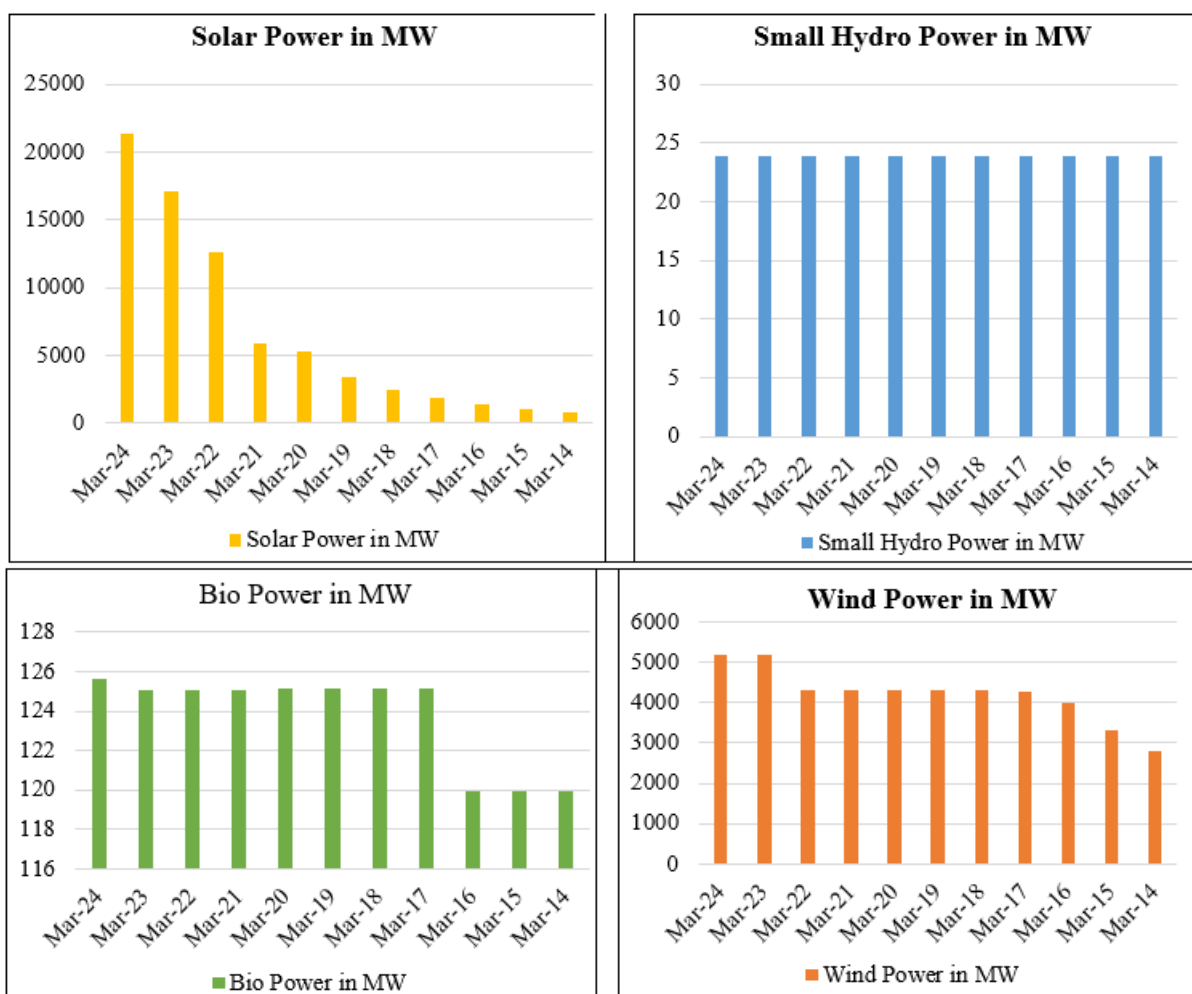
conventional energy sources” to encourage the use of renewable energy sources.

In 1999 the Government of Rajasthan announced a “policy for promoting generation of electricity from non -

**Installed Capacity of Renewable Power**

Year	Small Hydro Power (MW)	Wind Power (MW)	Bio Power (MW)	Solar Power (MW)	Total Power Capacity (MW)
Mar 24	23.85	5195.82	125.64	21347.58	26692.89
Mar 23	23.85	5193.42	125.08	17055.70	22398.05
Mar 22	23.85	4326.82	125.08	12564.87	17040.62
Mar 21	23.85	4326.82	125.08	5925.60	10401.35
Mar 20	23.85	4299.72	125.13	5275.27	9723.97
Mar 19	23.85	4299.75	125.13	3364.03	7812.73
Mar 18	23.85	4299.72	125.13	2431.66	6878.36
Mar 17	23.85	4281.72	125.13	1907.99	6338.69
Mar 16	23.85	3994.02	119.97	1346.09	5483.93
Mar 15	23.85	3308.52	119.97	1000.23	4452.57
Mar 14	23.85	2785.02	119.97	756.25	3685.09

Source: Ministry of New and Renewable Energy, Government of India



**Solar Energy**

Rajasthan is the preferred solar power generation hub in India. The government has developed many solar parks which are working very well and producing various megawatt of energy. The state has a solar potential of 142 GW. Some of the Solar parks are listed below: -

a) **Bhadala Solar Park.** When it comes to solar potential Bhadla solar park is Rajasthan’s treasure. The proposed total capacity of various phases I, II, III, IV is 2255 megawatt. It is

located in the Phalodi neighborhood of the Jodhpur region of Rajasthan. It is third largest solar park in the world covering an area of 56 square kilometer (14000 acres). There were four main phases of the project development:

**I- Phase:** It has 7 solar power plants with a compound capacity of 75 megawatt. Rajasthan Renewable Energy corporation limited (RRECL) collaborated with (RSPDCL) to create power plant.





*Bhadla Solar Park*

**II - Phase:** It has 10 solar power plants with 680 megawatts of installed capacity. Funding was given by MNRE for this phase.

**III - Phase:** This phase is constructed by the Surya Urja company of Rajasthan. There are 10 solar power plants with total of 1 GW of installed capacity.

**IV - Phase:** This phase is developed by Adani group and known as Adani renewable energy park. Rajasthan 500 megawatt energy comes from 10 solar energy installed in this phase.



function as a hub for the development of solar farms in Rajasthan.



#### SEEZ

The State Government of Rajasthan has made projects to develop Jaisalmer, Jodhpur, Barmer as a SEEZ (*solar energy enterprise zone*) power project of solar energy (140 megawatt) in Mathania is a landmark in this area, which is India's first hybrid solar power project. This is based on the integrated Solar combined cycle (ISCC) technology. The Rajasthan government is asking private sector also to invest in various physical and promotional incentives. These incentives will be given for both solar thermal and Solar photovoltaic project.

#### Wind Energy

Several factors influence together the potential of wind energy generation like wind speed, air density, blade radius, Coriolis force, the rotation of the earth, the difference in temperature gradients between land and sea and so on. India is at 4<sup>th</sup> position in among all countries in terms of wind sources. Rajasthan stands at 4<sup>th</sup> position with 5, 193.42 MW in wind energy generation in India. Gujarat rank first with 10, 415 MW. Tamil Nadu at 2<sup>nd</sup> position with 10, 124.5 4 MW, Karnataka at third position with 53.05 MW production followed by Rajasthan. The wind energy covers about 17.6% of total energy production of the state.

b) **Sambhar Ultra Mega Solar Power Plant.** This plant is located in Jaipur district. It supposed to be the site of 4000 - megawatt worth of Solar plant. 1<sup>st</sup> phase is generating 1000 - megawatt solar energy. Sambhar salt limited collaborated with BHEL, Solar Energy corporation of India, Power grid corporation of India limited to complete phase 1 of this project.

*Sambhar Ultra Mega Solar Park*

c) **Nokha Solar Park.** Nokha solar park is the second largest solar park. This park covers an area of 1850 hectares and it is situated in Nokha, Jaisalmer. This solar park is part of MOU between Government of Rajasthan and NTPC limited. This farm has a current installed capacity of 980 megawatt.

*Nokha Solar Park*

d) **Fatehgarh Solar Park.** It is located in Jaisalmer covering 9981 acres of land with the total capacity of 1500 megawatt. This is a joint project of Adani renewable energy park limited (AREPL) and Rajasthan Renewable Energy corporation (RRECL) which will

Wind power generation capacity in India has significantly increased in recent years as on 31<sup>st</sup> March 2024 the total installed wind power capacity was 45.887 GW. Wind Power capacity is mainly spread across the South West and North West States.

Most of the wind power plants in Rajasthan are located in Jaisalmer. The first wind power project in Rajasthan was established in 1999 in Amar Sagar, Jaisalmer. The Jaisalmer Wind Park with the capacity of 1600 MW is India's second largest wind farm. Suzlon Energy developed the project which consist of a collection of wind farms in Rajasthan Jaisalmer area including Amar Sagar, Badabaag, Tejuva, SodaModa etc. It is operational onshore wind farm. The Rajasthan government has taken many steps with MNRE to promote wind energy and identified locations of wind power like Devgad (Chittorgarh), Harshnath (Sikar), Khodal (Barmer) etc.



Jaisalmer Wind Park

### Biomass Energy

Agrarian India benefits greatly from its tropical position, abundant sunshine, precipitation for biomass production. Maharashtra is the leading producer of biogas in India. The Government of Rajasthan has announced "The policy for promoting for generation of electricity from biomass, 2010". The main source for biomass energy in Rajasthan is mustard husk and Julie flora. 92.5% of biomass energy goes for brick kinley and rest 7.5% is used for different purpose. The first biomass plant is set up by Kalpataru Power transmission Limited in Padampur, Ganganagar district of Rajasthan. The later are in Khatauli Uniara in Tonk, Kotputli in Jaipur, Kota, Chanderi in Chittorgarh, Rampur in Sirohi, Sangharia In Hanumangarh etc. There are 13 biomass energy plants are working in Rajasthan.

### Green Energy and Sustainable Development

Green energy has potential to mitigate various environmental challenges which are barrier in paving the way for sustainable development. Today the use of green energy resources has been recognised as a key factor in promoting sustainable development, which aims to meet the needs of the present generation without compromising the future. Sustainable development concept emerged in 1980s which Seeks to balance economics, social and environmental aspect to ensure a better future for all. Green energy plays a crucial role in sustainable development by reducing emission of greenhouse gasses which are by product of conventional energy resources. As compared to coal fired power plants electricity from green energy resources emits 90 to 99% less greenhouse gasses and produces 70 to 90% less pollutants. These are some key ways in which green energy contributes to sustainable development: -

- 1) **Reduce green house gas emission.** The use of green energy can reduce greenhouse gas like carbon dioxide, methane, chlorofluorocarbon, nitrous oxide etc emission

and help to mitigate the effects of climate change, current challenge in front of whole world. by using green energy that is solar and wind power etc. We can reduce our dependence on fossil fuels coal petroleum etc. and decrease the amount of harmful pollutants.

- 2) **Providing access to energy.** In developing countries like India clean energy use can reduce poverty and improve quality of life, as an access to green energy is essential for aspects of daily life such as lighting, cooking and heating etc. Solar energy is capable to fulfil these essential requirements of energy in daily life.
- 3) **Improving energy security.** Green energy increases energy security by reducing dependence on conventional energy sources and relying on local available resources such as solar and wind power. We can also reduce our dependence on import of foreign energy resources and become more self - sufficient.
- 4) **Supporting rural development.** As social development is one aspect of sustainable development, use of green energy can support rural development by providing them access to solar or wind energy, which can help to improve their quality of life, increase agriculture productivity by use of energy and stimulate their social growth.
- 5) **Creating jobs.** Green energy technology can create jobs and stimulate economic growth, particularly in the manufacturing and installation of green energy equipment's, for example production of solar panels and their installation, production of windmill blades and their installation etc.

### Challenges of Green Energy in Rajasthan

Some of the challenges faced by green energy on as follows:

- 1) **The initial cost of green energy is high.** The initial cost is so high that sometimes it is unaffordable. Their manufacturing and installation process like solar panel installation, heat bump cost is quite high as well as there is lot of risk too in initial stage of their installation.
- 2) **Renewable energy devices need recycling.** Though generating electricity from green energy resources produces way lower levels of pollution but these devices are subject to concern because manufacturing and their disposal process might emit pollution. Solar cell etc devices might be toxic, so we need to think of recycling process for them.
- 3) **Renewable energy is not available round the clock.** Renewable energy sources are natural forces that are strongly depends on the weather condition for example when it rains, PV panels can't generate electricity, when wind is not blowing, we can't generate wind energy. This uncertainty is the problem of relying on renewable energy resources for electricity generation.
- 4) **The efficiency of green energy technology is low.** Unfortunately, the efficiency of renewable technology is not that high compared with traditional energy conversion devices for example solar plant efficiency available in market is between 15 to 20%. On the other hand, traditional technology efficiency level up to 40 t60%.
- 5) **Renewable energy sites require a lot of space.** As compared to conventional power stations, more land is needed to establish renewable energy farms. Though this is not a big problem in Rajasthan as western Rajasthan has lot of barren lands for their installation.

- 6) **Stability of grid.** The main problem of green energy is the availability or stability of grid for solar and wind projects. Due to high penetration level of wind generated electricity, it is not possible for grid to absorb electricity.

## 2. Conclusion

Amidst all the challenges, on the one hand India have to focus on economic development and energy security, while on the other hand strict steps will have to be taken to tackle climate change and ensure sustainable energy transition to achieve the target of net zero by the year 2070. Energy transition that is moving from fossil fuels to clean and green energy sources is extremely necessary to face the serious challenges of climate change. From this point of view green energy can prove to be a leaping milestone in achieving this goal of electricity generation from conventional resources to free energy resources. Although moving towards green energy in a traditional way will control carbon emission, it is very important to assess its carbon footprints. Green energy play a crucial role in sustainable development by reducing greenhouse gasses and pollutant emission improving energy securities. Rajasthan is in a great position to achieve it's sustainable electricity goes through making necessary investment in green advancement. In today's scenario switching on green energy have become increasingly important as the world faces the challenges of mitigating the negative impacts of climate change and reducing the depends on exhausting and polluting fossil fuels. It will stimulate the economic, social and environmental growth, the various aspects of sustainable development. Green energy is environmentally friendly, more reliable, require less maintenance cost after installation. It will also help in increasing economic independence of the country and decrease the risk of an energy crisis and benefit the country's sustainable development.

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