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Renewable energy present status and future potentials in Haryana: An overview

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Abstract
This paper provides an overview of the current status and future potential of renewable energy in the state of Haryana, located in northern India. The paper highlights that Haryana has the potential to generate 6,793 MW of renewable power, with solar energy being the largest source of potential capacity. Despite the state's heavy reliance on coal and gas, Haryana has been exploring and investing in renewable energy sources, such as solar, small-hydro power, biomass, and waste-to-energy. The state government had targeted 3200 MW of solar energy capacity by 2022. The paper also discusses government initiatives and policies aimed at promoting renewable energy in the state. The paper concludes by discussing the challenges that need to be addressed in order to reach the government's targets.

Keywords: Renewable energy, solar power, Haryana, policies, and initiatives

Introduction
Renewable energy is gaining importance globally as countries aim to reduce their carbon footprint. India has set a target to increase non-fossil power capacity to 50% by 2030 and reduce emission intensity by 45% below 2005 levels. India also aims to achieve net-zero emissions by 2070, demonstrating its commitment to combatting climate change.
India is planning to add significant solar and wind capacity by 2031-32, with a target of 333GW and 134GW respectively, according to the draft National Electricity Plan 2022. Despite this, coal will continue to play a major role in India's energy mix. Renewables account for 29% of India's total capacity, and the country has doubled its installed capacity of renewables since 2016, including 58GW of solar and 41GW of wind energy. However, India missed its 2022 renewable energy target of 175GW, and to be 1.5°C compatible, renewables should reach 55-79% by 2030. India announced a 2030 target of 500GW non-fossil capacity at COP 26. Grid-scale energy storage will be critical in meeting this target, with India needing 70GW of storage capacity by 2031-32, according to the NEP2022 (Draft NEP , 2022; India, Policies and action, 2022). The government has introduced an Energy Storage Obligation and is promoting battery production through various incentives.
Haryana, a state located in northern India. As each state has their own role to play in achieving these targets, so is the Haryana. The demand for energy is constantly increasing in Haryana as it continues to grow and develop as a state. Haryana is playing fairly well in meeting in its energy demands (
Fig **1**). However, the dependence on coal has led to a significant increase in carbon emissions, contributing to climate change. To address this issue, Haryana has been exploring and investing in renewable energy sources, such as solar, small-hydro power, biomass, and waste-to-energy. These renewable energy sources have the potential to not only reduce the state's carbon footprint but also promote sustainability and energy security. Haryana government is making efforts to shift towards renewable energy, with solar energy being the most promising sector. The state government aims to generate 8,700 MW of renewable energy (Including large hydro) by 2030 and had targeted 3200 MW of solar energy capacity by 2022. In this paper, we have explored the potential for generation of renewable energy power in Haryana, the current status of renewable energy in Haryana, including how much renewable energy is currently being produced and what sources are being used (such as solar, wind, hydroelectric, etc.).

We also discussed the government initiatives or policies that are aimed at promoting renewable in the state. Finally, we discussed the challenges that may need to be addressed in order to reach the government's targets.

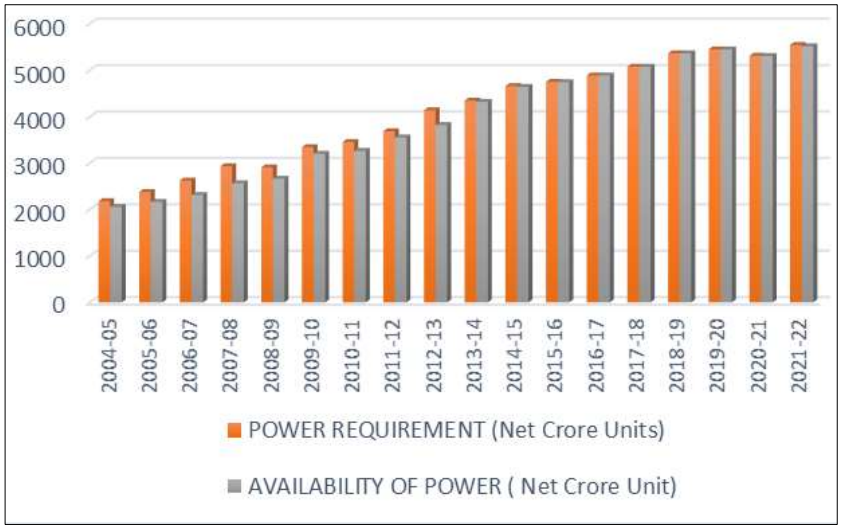

Fig 1: Comparison of Power Required and Power Available in Haryana (Handbook of Statistics on Indian States)

Haryana government is making efforts to shift towards renewable energy, with solar energy being the most promising sector. The state government aims to generate 8,700 MW of renewable energy (including large hydro) by 2030 and had targeted 3200 MW of solar energy capacity by 2022.

In this paper, we have explored the potential for generation of renewable energy power in Haryana, the current status of renewable energy in Haryana, including how much renewable energy is currently being produced and what sources are being used (such as solar, wind, hydroelectric, etc.). we also discussed the government initiatives or policies that are aimed at promoting renewable in the state. Finally, we discussed the challenges that may need to be addressed in order to reach the government's targets.

Potential for Generation of Renewable Power

Haryana has a total potential for renewable power generation of 6,793 MW (excluding large hydro), with solar energy being the largest source of potential capacity at 4560 MW (67.12% of total renewable potential). Wind power potential is much lower at 419 MW (6.17%), while small-hydro power has a potential capacity of 107 MW (1.58%). Biomass power has a potential capacity of 1333 MW (19.62%), and bagasse-based cogeneration and industrial waste to energy have a potential capacity of 350 MW (5.15%) and 24 MW (0.35%) respectively. The state government has already taken steps to promote solar energy and attract investment in the sector.

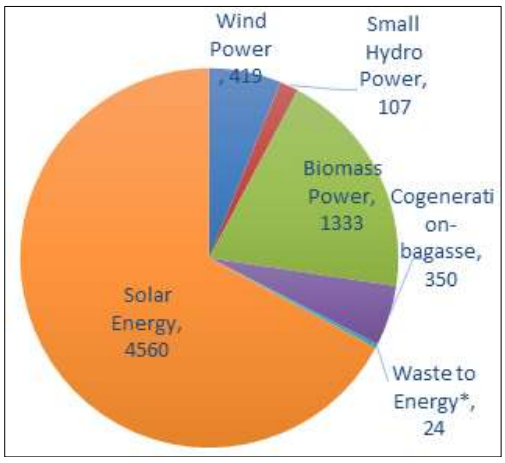

Fig 2: Source wise estimated potential of renewable power in Haryana (in MW) (Energy-statistics-India-2022)

Energy Sector in Haryana

The energy mix of Haryana is currently heavily reliant on thermal power sources, with almost 71% of the installed capacity coming from coal and gas (We also discussed the government initiatives or policies that are aimed at promoting renewable in the state. Finally, we discussed the challenges that may need to be addressed in order to reach the government's targets.). This is due to the historical reliance on traditional sources of energy, which has been a mainstay of the state's energy sector for several decades. However, over the past few years, there has been a steady increase in the installation of renewable energy resources, such as solar, small-hydro power, biomass, and waste-to-energy, suggesting that Haryana is on track to achieve a more balanced energy mix in the future (
Fig **4**).

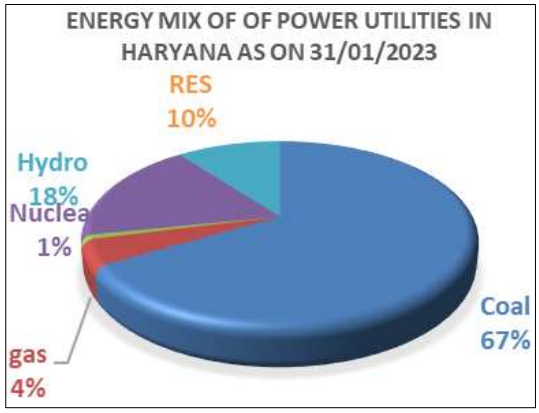

Fig 3: Energy mix of power utilities in Haryana as on 31/01/2023

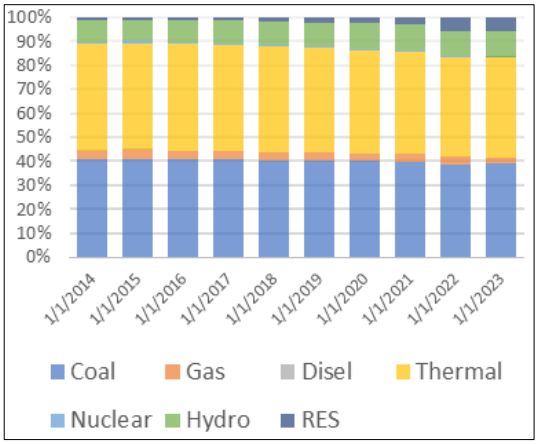

Fig 4: Energy mix comparison diagram of Haryana

Installed capacity of power utilities in Haryana has almost increased 1.56-fold with a CAGR of 4.54 from 2014 to Jan 2023. As of January 2023, renewable energy resources (excluding hydro) contribute only 10% to the installed capacity in Haryana, indicating that there is still a long way to go in terms of achieving a balanced energy mix. However, the installed capacity of renewable energy has increased almost 8-fold from March 2014 to Jan 2023, with a compound annual growth rate (CAGR) of 23.09% (Table 1: Installed Capacity Report (Installed Capacity Report) This growth rate is impressive and shows that Haryana is making significant progress in transitioning towards renewable energy.

Table 1: Installed Capacity Report (Installed Capacity Report)

Installed Capacity (In Mw) of Power Utilities in Haryana Including Allocated Shares in Joint & Central Sector Utilities										
Date	**Coal**	**Lignite**	**Gas**	**Diesel**	**Thermal**	**Nuclear**	**Hydro**	**RES**	**Renewable total**	**Total**
31-03-2014	6082.03	0	560.29	3.92	6646.24	109.16	1400.6	167.3	1567.9	8323.3
31-03-2015	6527.53	0	560.29	3.92	7091.74	109.16	1416.14	180.7	1596.84	8797.74
31-03-2016	6527.53	0	560.29	0	7087.82	109.16	1456.83	185.29	1642.12	8839.1
31-01-2017	8070.1	0	685.61	0	8755.72	100.94	1948.21	251.3	2199.51	11056.16
31-03-2018	8095.5	0	685.61	0	8781.12	100.94	1948.21	411.75	2359.96	11242.01
31-03-2019	8095.5	0	685.61	0	8781.12	100.94	1966.52	419.42	2385.94	11267.99
31-01-2020	8660.57	0	685.61	0	9346.18	100.94	2312.02	531.3	2843.32	12290.44
31-03-2021	8682.61	0	685.61		9368.23	100.94	2318.52	693.19	3011.71	12480.87
31-03-2022	8636.58	0	685.61	0	9322.19	100.94	2324.62	1242.13	3566.75	12989.88
31-01-2023	8638.39	0	581.59		9219.98	100.94	2324.62	1335.97	3660.59	12981.51

RES include SHP, BP, U&I, Solar and Wind Energy.
SHP=Small Hydro Project (≤ 25 MW), BP=Biomass Power, U&I=Urban & Industrial Waste Power, RES=Renewable Energy Sources

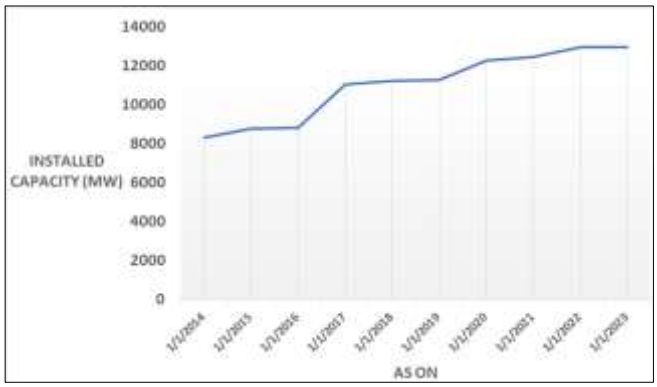

Fig 5: Installed capacity (in mw) of power utilities in Haryana including allocated shares in joint & central sector utilities.

Furthermore, the growth rate of renewable energy in the year 2021-22 over 2020-21 was an impressive 79.19%, indicating that the state is accelerating its transition towards renewable energy (Fig **6**). While there is still a significant gap between renewable energy and thermal power sources, the rate of growth for renewable energy is promising and shows that Haryana is moving in the right direction.

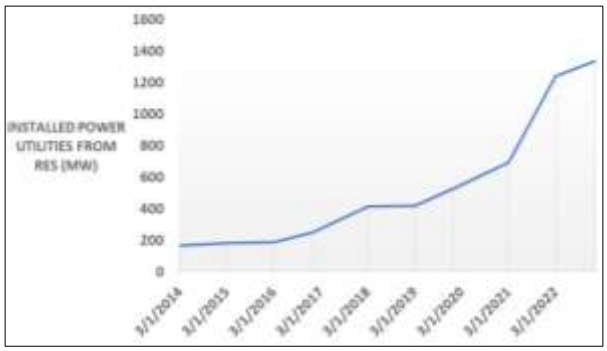

Fig 6: Installed power utilities in RES.

Overview of Solar Energy Technology in Haryana
Roof Top solar Power plant

Fig 7: Solar Roof top power plant

A solar rooftop power plant is a type of solar power plant that is installed on the rooftop of a building, such as a home or a commercial building. The solar panels used in a solar rooftop power plant are designed to generate electricity from sunlight and are typically made of semiconductor materials like silicon.
When sunlight hits the solar panels, it produces a flow of direct current (DC) electricity. This DC electricity is then sent to an inverter, which converts the DC electricity into alternating current (AC) electricity that can be used to power appliances and electronics in the building.
Some solar rooftop power plants may also include battery storage backup, which allows excess energy generated during the day to be stored for use at night or during periods of low sunlight. The size and capacity of a solar rooftop power plant can vary depending on

the building's energy needs and the amount of sunlight the rooftop receives. Average solar irradiation in Haryana state is 1156.39 W / sq. m. On an average, a 1kWp solar rooftop plant can generate 4.6 kWh of electricity per day, assuming 5.5 sunshine hours. Therefore, the total electricity generated by a 10kW solar power plant in a year is 13.8 MWh, and over its lifespan of 25 years, it generates 345 MWh of electricity. Such a solar power plant can effectively reduce 283 tons of carbon dioxide emissions, which is equivalent to planting 453 teak trees over its lifetime.

Solar Agricultural Pump

Fig 8: Solar Agricultural Pump

Solar Agricultural Pump technology is a system that uses solar panels to power water pumps for irrigation in agriculture. It involves the installation of solar panels on farms or fields to capture the energy from the sun and convert it into electricity, which is then used to run the water pumps that draw water from underground or surface sources for crop irrigation. The use of solar-powered pumps helps farmers to save on diesel or electricity costs, and also reduces greenhouse gas emissions. This technology is particularly useful in areas with abundant sunlight but inadequate access to grid electricity or high diesel costs.

Solar water heater

In a domestic solar water heater system, the solar collector absorbs sunlight and converts it into heat, which is then transferred to the water that flows through the collector. The heated water is then stored in an insulated tank for later use. The solar water heater system can be used in homes, hotels, hospitals, and other places where hot water is required.

There are two types of solar water heaters: Flat Plate Collectors (FPC) and Evacuated Tube Collectors (ETC). In hard water areas with high chlorine content, FPC solar water heaters should have a heat exchanger to prevent scale build up copper tubes of FPC not only reduce the flow of water but also decrease their thermal efficiency. Scale build up in c ETC systems may experience reduced performance due to salt deposition on glass tubes, which can be cleaned yearly.

Fig 9: Solar water heater

Solar Parks

Solar parks are large-scale solar power plants that generate electricity by harnessing solar energy through photovoltaic (PV) panels or concentrated solar power (CSP) technology. The Haryana government has set up 20 energy parks under the Renewable Energy Park Scheme to create awareness and demonstrate the applications of renewable energy sources. The MNRE provides financial assistance of up to 75% of the project cost, ranging from Rs.1.00 lakh to Rs.10.00 lakh, depending on the park's size. The energy parks are established in various institutions and organizations across 18 districts of the state (Renewable Energy Park Scheme).

Major Ongoing Schemes and Policies Related to Renewable Energy Sources

- Haryana Solar Power Policy 2016: Haryana Solar Power Policy 2016 aims to promote solar power development in the state by offering incentives and subsidies. The policy provides various benefits such as generation-based incentives, exemption from electricity duty and wheeling charges, and net metering facilities. The state has set a target of achieving 3200 MW of installed solar power capacity by 2022, which includes 1,600 MW of rooftop solar capacity. To further promote the use of renewable energy sources, the Haryana government has also increased the Renewable Purchase Obligation (RPO) requirements from 3% to 8%. The policy mandates that all new buildings constructed on a plot size of 500 square yards or more must have a minimum of 1 kWp solar power installation, and all government buildings must have a minimum of 3 kWp solar power installation. The policy promotes the development of solar parks and provides for a single-window clearance system to expedite the approval process for solar power projects.

The Haryana government has set a target of installing 50,000 solar pumps in 2022-23 and plans to install solar power plants in all government offices, higher education institutes, and universities where energy requirement is more than 10 kW in the next two years (From director desk).

Haryana Bio-Energy Policy 2018:

The Haryana Bio-Energy Policy 2018 was introduced to promote the use of biomass to produce energy, including electricity, biogas, bio-CNG, bio-manure, and biofuels, to reduce dependence on conventional energy sources and improve the environment and soil health. Haryana, an agrarian state, has surplus biomass availability of 8416 thousand tons, which has a potential of generating 1000 MW of power or 11.5 lac ton of bio-CNG. The policy's objectives include creating a conducive environment to attract private investment in biomass projects, supporting research and development, demonstration, and commercialization of new technologies. The policy aims to achieve a target of a minimum of 150 MW biomass-based power generation or equivalent by 2022. The policy provides incentives, including land and clearances for projects, grid interfacing, power evacuation, exemption from stamp duty charges, and fee exemptions by the Pollution Control Board.

It also facilitates biomass projects' leasing on Panchayat and agricultural land and exempts them from land use approval, EDC, scrutiny fee, and infrastructure development charges. The promotion of biomass-based projects not only reduces dependence on conventional energy sources but also improves the environment, soil health, and creates alternative streams of income for farmers and employment in rural areas. The policy is crucial as open crop residue burning causes the emission of air pollutants, ultimately affecting atmospheric quality and climate (Haryana Bio-energy Policy 2018). Two paddy straw-based power projects of 15 MW each have been commissioned in 2021-22 at Kurukshetra and Kaithal while other two of 9.9.MW each at Fatehabad and Jind are likely to be commissioned soon to tackle the problem of straw burning in fields.

- Haryana Small Hydro Power Policy 2018: This policy aims to promote the development of small hydro power in the state by offering incentives and subsidies to individuals and businesses that set up small hydro power projects. The policy targets to install 50 MW of small hydro power capacity by 2022. The promotion of biomass-based projects not only reduces dependence on conventional energy sources but also improves the environment, soil health, and creates alternative streams of income for farmers and employment in rural areas. The policy is crucial as open crop residue burning causes the emission of air pollutants, ultimately affecting atmospheric quality and climate.
- Haryana Renewable Energy Development Agency (HAREDA): HAREDA is a nodal agency for the promotion and development of renewable energy sources in the state. It offers various schemes and programs to promote renewable energy, including solar rooftop installation, solar water heating systems, and solar street lighting.

The Haryana Renewable Energy Development Agency (HAREDA) has implemented various schemes to promote the use of solar energy in the state (Departmental Schemes). One such scheme is the Installation of Grid Connected Rooftop Solar Power Plant, which provides financial assistance of 30% of the benchmark cost, or INR 20,000 per kWp, for the installation of power plants ranging from 1 kWp to 500 kWp for all eligible users. Additionally, registered Scheduled Caste and Backward Classes Dharmshalas can avail of 75% state financial assistance for Grid Connected Rooftop (GCRT) solar power plants, with or without a battery bank, under the CAPEX mode, while state government departments/boards/corporations running social sector institutes can receive 50% financial assistance for the installation of GCRT solar power plants.

The LED Based Solar Home Lighting System (MANOHAR JYOTI) is another scheme that provides lighting and air cooling to households in the state. It consists of a solar module, battery, LED luminaries, DC ceiling fan, and USB port and has a system cost of INR 22,500, with a cost subsidy pattern of 90% for the general scheme under SCSP component and 10% for the user share.

For the fiscal year 2022-23, the state has allocated a budget provision of 350 lakh for providing state share subsidies for LED-based solar street lighting systems and LED-based high mast lighting systems. Non-commercial institutions/organizations, Zila Parisads, Gram Panchayats, Block Samitis, etc., are eligible for a state share subsidy of Rs 4,000.00 per unit for LED-based solar street lighting systems and Rs 20,000.00 per unit for LED-based high mast lighting systems.

Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM Kusum)

The Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM-KUSUM) is a nationwide scheme aimed at providing clean energy to farmers in India. The scheme comprises of three components, namely, Component A, B, and C. The scheme aims to install additional solar capacity of 30.80 GW across the country (Draft NEP, 2022).

Component A of the PM-KUSUM scheme in Haryana aims to install grid-connected solar power plants with a total capacity of 10 GW. As of 31/12/2022, the sanctioned capacity for grid-connected solar power plants in Haryana is 65 MW, out of which 2.25 MW has already been installed (PM Kusum).

Component B of the PM-KUSUM scheme focuses on installing standalone solar pumps. Haryana is one of the leading states in the country with approximately 40,216 (standalone solar pumps installed out of 197,655 sanctioned standalone solar pumps as of 31/12/2022 (PM Kusum). The state government provides a 75% subsidy (State+MNRE) to individual farmers, water user associations, gaushalas, and community/cluster-based irrigation systems for the installation of standalone solar agriculture pumps of up to 10 HP. The subsidy is provided for the replacement of existing diesel agriculture pumps/irrigation systems in off-grid areas where grid supply is not available. Priority is given to small and marginal farmers. The total solar power generated from standalone solar power pumps installed under PM-KUSUM in Haryana is 58068.8 MWh, as shown in Figure 10. This has resulted in a significant reduction of 46455.07 tons of carbon footprint, as indicated in Figure 11. Among all the districts in Haryana, Sirsa has emerged as the top district in terms of total solar power generation.

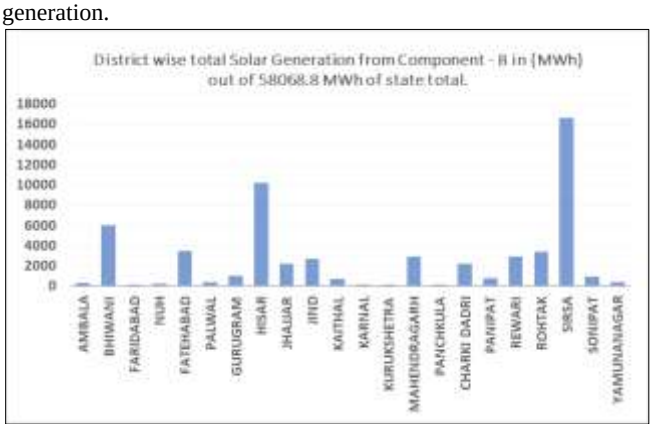

Fig 9: Total Solar Generation from Component B (PM-KUSUM Haryana)

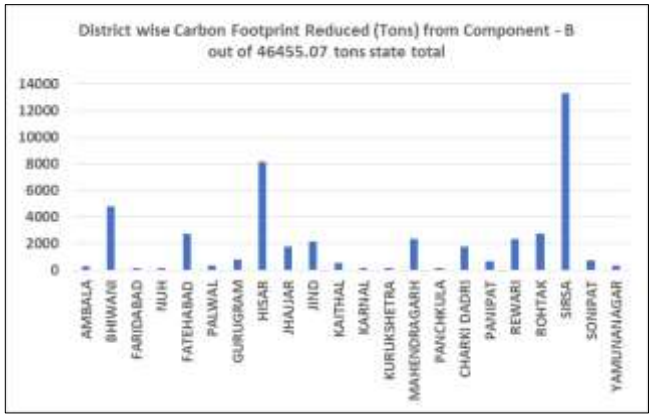

Fig 10: Carbon footprint reduction form component B (PM-KUSUM Haryana)

Component C of the PM-KUSUM scheme focuses on solarizing grid-connected agricultural pumps. Haryana has 65,079 total sanctioned Feeder Level Solar (FLS) as of now (PM Kusum).

Discussion and Conclusion

In conclusion, the paper provides an overview of the present status and future potential of renewable energy in Haryana, a state in northern India. While the state has made progress in increasing its renewable energy capacity, its heavy reliance on thermal power sources still poses a significant challenge in achieving a more balanced energy mix. The paper highlights the potential of solar energy as the most promising sector for renewable energy generation in Haryana, with a target of 4,700 MW by 2022. Additionally, the state has significant potential in other renewable

energy sources such as small-hydro power, biomass, and waste-to-energy.

The government of Haryana has taken initiatives and policies to promote renewable energy, including attracting investment in the sector. However, to achieve the target of generating 8,700 MW of renewable energy by 2030, more efforts need to be made to address challenges such as the high cost of renewable energy and grid integration. The paper concludes that transitioning towards renewable energy sources can not only reduce the state's carbon footprint but also promote sustainability and energy security.

There are several challenges that need to be addressed to achieve these goals. One of the key challenges is the need for collaboration and coordination between various stakeholders, including the government, industry, and civil society. The transition to a low-carbon economy requires collective action and partnerships, and failure to coordinate effectively can result in limited progress towards the government's targets.

Additionally, there is a need for significant investments in research and development of clean technologies and infrastructure, which can be expensive and require significant financial resources.

Finally, there is a need for public awareness and engagement, as individuals and communities play a crucial role in achieving the government's targets. Raising awareness about the benefits of reducing emissions and encouraging changes in individual behavior can help to drive the transition to a low-carbon economy.

Overall, while the government's targets are ambitious, addressing these challenges will be crucial to achieving them. By taking a collaborative and coordinated approach, investing in clean technologies and infrastructure, and engaging with the public, it is possible to reach the government's targets and mitigate the effects of climate change.

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