Energy Ladder Progression in Indian Schools: A State-level Analysis

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Abstract

Advancing along the energy ladder is an essential undertaking within the domain of energy access, playing a pivotal role in fostering sustainable socio-economic development, encompassing sectors such as health, education, and beyond. This progression occurs as households or institutions transition from utilizing polluting and inefficient fuels—such as firewood and diesel—to adopting cleaner, more sustainable, and cost-effective energy alternatives, including liquefied petroleum gas (LPG), compressed natural gas (CNG), and renewable energy sources. Within the educational sector, the consistent availability of sustainable and affordable energy solutions is integral to fortifying the infrastructure of schools, enhancing the resilience of communities, and stimulating economic growth. According to the most recent UDISE report, which assesses the provision of various infrastructural facilities in schools, 89% of schools in India had access to electricity from diverse sources in the academic year 2021-22, a marked increase from 86.90% in the previous year. Of the schools with electricity access in 2021-22, 6.7% had installed solar panels. This represents a notable shift from coal-dependent electricity toward renewable energy solutions, though the transition remains far from complete. Significant efforts are still necessary at both institutional and policy levels to effect a large-scale transformation from coal-based energy to renewable energy sources in educational institutions across the nation.

Keywords: Energy Ladder, Renewable energy, solar panels, Electrification of Schools, Solarisation.

I. Introduction

Education institutions need electricity for lighting, heating, cooling, cooking, water supply and information and communication technology

(ICT) services. SDG 4 which focuses on quality education aims to "*ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*" by 2030[1]. It has been observed that low rates of electricity access results in poor academic performance, lower attendance and leads to lower level of staff retention[2] (UNICEF 2019). In fact, a positive correlation has been examined between electrification and better education outcomes. An evaluation study by ADB (Rauniyar, et al 2010) found that in Bhutan, rural electrification resulted in 0.65 additional years of schooling for girls and 0.41 additional years for boys.

UNESCO (2019) reports that Sub-Saharan Africa has the lowest electricity access in primary schools (35%), followed by South Asia (51%) and Latin America (87%), with over 230 million children globally studying without electricity. Access to sustainable energy enhances enrolment, sanitation, staff retention, lighting, and extended school hours, thus contributing to SDG 4 through progress on SDG 7.

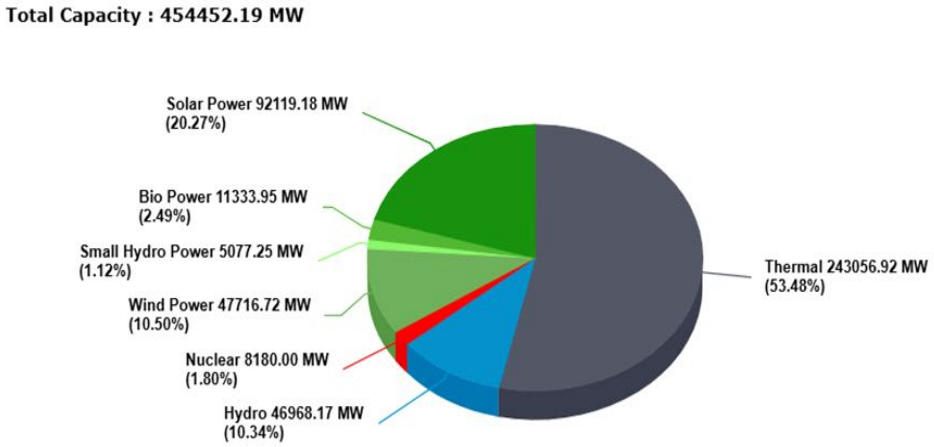

Figure 1. Category Wise Installed Capacity (As of 25/11/2024)

Source: https://npp.gov.in/dashBoard/cp-map-dashboard

Figure 1 depicts the installed capacity of various sources of electricity. Over the years the share of solar, wind & other renewable energy sources has increased by almost 11 percent[3], indicating an energy transition towards the use of cleaner energy sources. Progress in SDG 7, with the use of solar power, which is at 20 percent, will help in moving up the energy ladder and thus reflect the country's growing reliance on cleaner and sustainable energy sources. It will thereby help in achieving SDG 4 through access to sustainable and modern

use of electricity sources in schools. In this respect, the solarization of schools is an important step towards this energy transition and helps in progressing towards a more resilient energy future with less dependence on fossil-based sources of energy.

Energy ladder is a concept in which as the income of the households increases, it moves up the ladder from the use of dirty fuels like firewood, diesel to the use of cleaner and affordable fuels like renewable energy. But what about the energy ladder at the community level? This paper aims to see the energy ladder progression made in schools in India and its impact on the learning environment for students. The paper aims to explore how adoption of solar energy at state level in schools has moved up the energy ladder, from coal-based electricity to renewable sources of energy. What are the factors contributing to this change? How have states fared in the adoption of renewable energy?

II. Literature Review

Without electricity, access to basic and digital education remains a distant dream, especially in rural and remote areas which are unelectrified or under electrified. In 2021, 770 million people did not have access to electricity.[4] Practical Action (2013) observed that in Bangladesh, teachers faced difficulty to teach in very low light conditions. Additionally, during rainy weather, schools had to be cancelled in the Philippines as classrooms were not sufficiently well lit for students and teachers (Valerio, 2014).

By 2020, 75.71 percent of primary schools had access to electricity, 86 percent of lower secondary schools had it, and 90 percent of upper secondary schools had it. A GEM report (2023) found that the share of schools with electricity increased marginally from 30 percent in 2015 to 32 percent in 2020 in Central and Southern Asia and Sub-Saharan Africa.

Investment in expansion of the national electricity grid is capital intensive and time consuming. As an alternative solution, the use of decentralised renewable energy (DRE) in schools can help in improving the education outcomes. UNESCAP has defined a decentralized energy system which is "*characterized by locating of energy production facilities closer to the site of energy consumption."*[5] DRE technologies are powered by renewable sources like solar and wind. In terms of solar PV generation,

solar panels installed to turn sunlight into an electric current, is the most common preference for decentralised power generation. In 1968, the first solar panel was installed in a primary school in Niger[6]. In Palestine, installing solar PV systems in Al-Dahriya secondary public school, not only helped Palestinians become energy independent but it also resulted in surplus electricity generation (Alsamamra and Shoqeir, 2021). The "Solar Schools" program in India provides rural schools with solar panels, to ensure a reliable source of electricity, and help in improving the quality of education (Lottu et al. 2023).

To improve education outcomes and build climate resilient schools, UNICEF supported the connection of 150 learning centres to renewable energy which benefited more than 3 lakh Rohingya children staying in refugee camps, in Cox's Bazaar, Bangladesh (UNICEF 2022). With solar energy gaining traction, one in 10 K-12 public and private schools across New Jersey to California, were running on solar energy by early 2022 (Buckley, 2022). With electrification of schools, facilities like clean drinking water, cooked and nutritious meals and primary health services can be offered (UNICEF 2019). In Lagos, a solar powered floating school was installed for the Makoko water community which provided education to more than 100 children (Hsu, 2017). Solar-powered schools help children understand the need for clean energy and help nurture a culture of sustainability (Kamat & Nasnodkar, 2019; Khin & Jayaranjan, 2022; Shrimali & Rohra, 2012). Such innovative approaches can make solar energy more accessible and affordable in countries where there is a greater solar energy potential and help education institutions climb up the energy ladder progression.

Silva et al. (2024), analysed the average investment and estimated monthly savings from the installation of solar panels on 310 public schools in Sergipe, Brazil. The results showed that solar energy in schools resulted in a return on investment in the short and medium term, making the investment viable. Lottu et al. (2023) highlight that in the long term, economic benefits consist of cost savings and revenue generation through surplus electricity production (Silva et al. 2024). The use of solar energy systems in schools helps in providing lighting, installing internet equipment, and laptop charging facilities (Schinca and Amigo 2010). Khan et al. 2015, installed solar power systems in different schools in the Khyber region of Pakistan and found that the adoption of solar projects necessitates low initial cost, less maintenance,

and tends to be economical. Yet, challenges in the scalability of solar projects are the financial barrier with high initial costs of installation and infrastructure issues (Hosseini, 2019), especially for schools with limited budgets (Lottu et al. 2023).

In India, according to the latest UDISE[7] report, which examines various infrastructure facilities being provided in schools, 89% of schools in India will have electricity access from various sources in 2021-22, which has increased from 86.90% in 2020-21. This figure stood at 77% in 2018-19, an improvement of 12% over four years. Out of these schools having electricity access in 2021-22, 6.7% of schools have solar panels installed. Substantial efforts are required to make a significant shift from coal-based access to renewable-based access to electricity at an institutional and policy level across the country. Rising the energy ladder is very crucial in the realm of energy access and sustainable socio-economic development including health and education besides other aspects.

Given the background, the solarization of schools in India has been at a slow pace and there is a need to examine the data and policies supporting it to scale this up. Given the recent data from the UDISE report, solar panels have been made available as a renewable energy source, to power schools in the country. The objective of the paper is to explore how schools with different ownerships have moved up the energy ladder, from coal-based electricity to renewable sources of energy. What are the factors contributing to this change? How have states fared in the adoption of renewable energy?

III. Data and Methodology

This study explores the accessibility, awareness, and progression made from fossil-based electricity to the use of solar electricity in schools across the country. The study uses secondary data provided in the Unified District Information System for Education Plus (UDISE+) report for 2021-22. The paper analyzes the installation of renewable energy under two broad areas: (i) National and (ii) State. A comparative data analysis is conducted to investigate the extent of solarization in educational institutions. Policy documents related to the solarization of schools, and case studies highlighting the impact of reliable, sustainable, and accessible electricity on educational outcomes are studied too. Moreover, this study uses the UDISE+ report data, which has

reported the adoption of solar panels for the first time in the country for the year 2021-22.

IV. Energy ladder progression for Indian schools

Access to reliable electricity is crucial for achieving quality education. The Economic Survey (2021) observed that states with lower literacy rates have low electricity rates in schools and vice versa. The Survey further highlighted a linkage between the Net Enrolment Ratio and certain states with low, medium, and high Human Development Indexes.[8]

Installation of solar panels in educational institutions is important as it ensures an uninterrupted supply of electricity, hence reducing the dependency on traditional sources of energy and contributing to a greener future. The supply of electricity in schools becomes more important in rural areas, where despite the electricity connection, the supply of electricity is unreliable. In recent years, the adoption of solar panels in schools across the country has been growing. In this regard, the UDISE report (2021-22) for the first time has started reporting data on several schools having solar panels across India.

Table 1 shows the number of Schools having solar panels at all India level and state-wise. At all India level, Government schools and private unaided schools had the highest number of solar panels available in 2021-22. There are more than 10 lakh government schools in the country, out of which a little over 54 thousand government schools have installed solar panels. This shows the commitment and intent of the government to promote renewable energy as a source of electricity in the education sector. National Institute of Rural Development and Panchayati Raj (NIRDPR) provided solar installations for lighting and cooling needs in 26 government schools in rural Telangana[9]. With the help of this initiative, schools were able to achieve their electricity needs by installing roof-top solar panels along with a battery and inverter system and all the classrooms have been provided with two fans and two lights. To ensure uninterrupted power supply in government schools, the Punjab Government has given its approval for the installation of solar rooftop panels in 965 government schools across the state, including 161 in Ludhiana[10]. This large-scale project shows the state government's commitment to renewable energy sources.

Table 1: Number of Schools having Solar panels available, 2021-22

India/ State/ UT	Total Schools					Schools with Solar Panels availability					Percentage of Schools with Solar Panels availability				
	All management	Govt.	Govt. aided	Pvt. unaided	Others	All management	Govt.	Govt. aided	Pvt. unaided	Others	All management	Govt.	Govt. aided	Pvt. unaided	Others
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
India	1489115	1022386	82480	335844	48405	99678	54309	6298	35892	3179	6.7	5.3	7.6	10.7	6.6
Andaman and Nicobar Islands	416	342	2	72	0	13	10	0	3	0	3.1	2.9	0	4.2	0
Andhra Pradesh	61948	45137	1542	15058	211	3483	1756	88	1620	19	5.6	3.9	5.7	10.8	9
Arunachal Pradesh	3603	2985	68	503	47	176	101	15	56	4	4.9	3.4	22.1	11.1	8.5
Assam	60859	45490	3841	5852	5676	1864	1557	20	262	25	3.1	3.4	0.5	4.5	0.4
Bihar	93165	75558	742	8097	8768	7691	5686	62	1001	942	8.3	7.5	8.4	12.4	10.7
Chandigarh	233	123	7	76	27	158	91	5	61	1	67.8	74	71.4	80.3	3.7
Chhattisgarh	56512	48743	417	7063	289	2085	1844	22	216	3	3.7	3.8	5.3	3.1	1
Dadra & Nagar Haveli and Daman & Diu	460	388	8	63	1	55	55	0	0	0	12	14.2	0	0	0
Delhi	5619	2762	247	2610	0	1580	1076	44	460	0	28.1	39	17.8	17.6	0
Goa	1510	814	557	139	0	28	8	11	9	0	1.9	1	2	6.5	0
Gujarat	53851	34699	5590	13559	3	2963	1398	366	1199	0	5.5	4	6.6	8.8	0
Haryana	23726	14562	16	8261	887	3898	1527	3	2196	172	16.4	10.5	18.8	26.6	19.4
Himachal Pradesh	18028	15380	0	2646	2	806	624	0	182	0	4.5	4.1	0	6.9	0
Jammu and Kashmir	28805	23173	1	5526	105	2583	2133	1	435	14	9	9.2	100	7.9	13.3
Jharkhand	44855	35840	1175	1559	6281	3215	2416	77	215	507	7.2	6.7	6.6	13.8	8.1
Karnataka	76450	49679	7110	19650	11	9817	5068	1079	3669	1	12.8	10.2	15.2	18.7	9.1
Kerala	16240	5010	7183	3164	883	1108	436	273	351	48	6.8	8.7	3.8	11.1	5.4
Ladakh	978	838	28	112	0	154	112	7	35	0	15.8	13.4	25	31.3	0
Lakshadweep	38	38	0	0	0	1	1	0	0	0	2.6	2.6	0	0	0
Madhya Pradesh	125582	92695	740	30345	1802	5572	3845	46	1625	56	4.4	4.2	6.2	5.4	3.1
Maharashtra	109605	65639	24037	19268	661	11491	6543	2583	2329	36	10.5	10	10.8	12.1	5.5
Manipur	4617	2889	583	1010	135	350	53	6	277	14	7.6	1.8	1	27.4	10.4
Meghalaya	14600	7783	4172	2120	525	268	123	74	55	16	1.8	1.6	1.8	2.6	3.1
Mizoram	3911	2563	230	1034	84	44	12	6	22	4	1.1	0.5	2.6	2.1	4.8
Nagaland	2718	1960	0	757	1	227	182	0	45	0	8.4	9.3	0	5.9	0
Odisha	62291	49072	5807	6104	1308	2265	1743	156	336	30	3.6	3.6	2.7	5.5	2.3
Puducherry	736	422	33	281	0	25	6	0	19	0	3.4	1.4	0	6.8	0
Punjab	27701	19259	450	7978	14	2489	1774	26	688	1	9	9.2	5.8	8.6	7.1
Rajasthan	106373	68948	0	34826	2599	4350	2011	0	2293	46	4.1	2.9	0	6.6	1.8
Sikkim	1259	864	19	376	0	84	62	2	20	0	6.7	7.2	10.5	5.3	0
Tamil Nadu	58801	37636	8323	12396	446	1910	852	173	868	17	3.3	2.3	2.1	7	3.8
Telangana	43083	30023	700	12193	167	2011	1008	30	965	8	4.7	3.4	4.3	7.9	4.8
Tripura	4929	4262	43	363	261	114	85	1	22	6	2.3	2	2.3	6.1	2.3
Uttar Pradesh	258054	137024	8113	97808	15109	22743	6741	1081	13757	1164	8.8	4.9	13.3	14.1	7.7
Uttarakhand	22815	16484	608	5225	498	924	523	35	347	19	4.1	3.2	5.8	6.6	3.8
West Bengal	94744	83302	88	9750	1604	3133	2847	6	254	26	3.3	3.4	6.8	2.6	1.6

Source: UDISE+ 2021-22

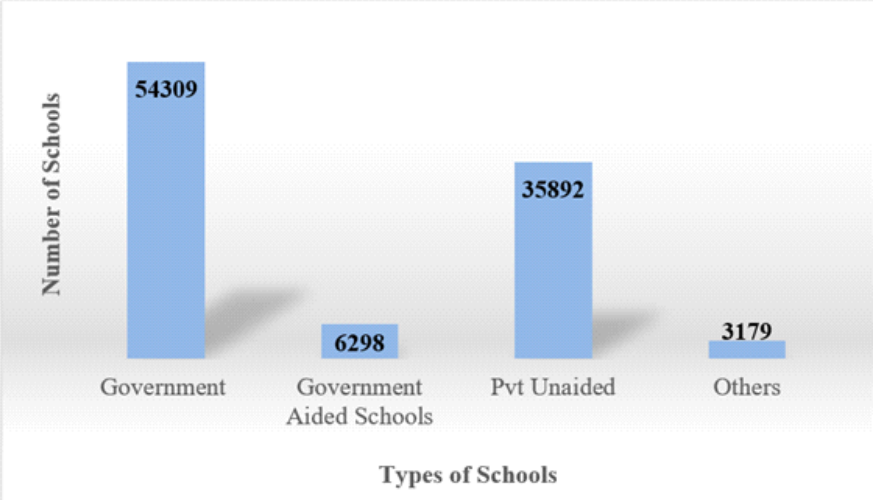

Figure 2: Number of schools with solar panels, UDISE Report 2021-22

In order to reduce the carbon footprint, several private schools in Jamshedpur, had installed rooftop solar panels, promoting renewable energy.[11] The solar electricity thus generated is sufficient during school hours. Adoption of solar energy in educational institutions helps in saving on electricity bills and also inspire the young generation to become agents of change and understand the importance of green energy and its use in the future.

In educational institutions, rising up the energy ladder does mean adopting solar technology but it also results in stacking up of energy sources. Due to frequent power cuts, supply of electricity hampers teaching in the classroom and use of the internet in computer labs, due to which schools have adopted solar energy in addition to the existing grid connection. This is known as the stacking model where there is an option of using multiple energy sources at the same time (Serrano et al. 2019). In a stacking model, the primary source of electricity is through the national grid and solar energy can be used as a backup power source in schools by installing solar panels that generate electricity during sunny days and store it in batteries for use during power outages.

V. Analysis for Indian states

State-wise data in Table 1 shows that states like Assam and West Bengal reported 3.1% and 3.3% of Schools with Solar Panels. With limited access to electricity in rural areas, the installation of solar panels in schools will help to "*enhance education opportunities, improve engagement, and provide a sustainable learning environment*."[12] Kerala

and Andhra Pradesh are making continued investments in solarizing their schools with 6.8% and 5.6% of schools having solar panels (UDISE 2021-22).

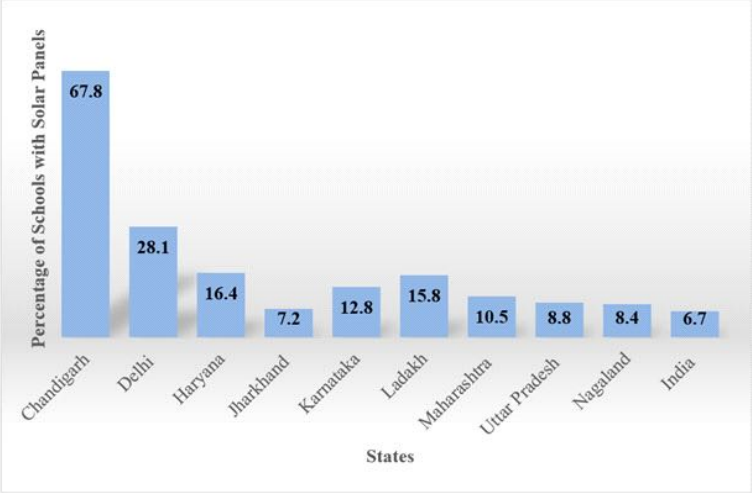

Figure 3: State-wise solarisation of schools in India, UDISE Report 2021-22

Figure 3 represents the states that were doing better than the national average of 6.7 percent in the solarisation of schools in India. The high adoption rate in Uttar Pradesh with 8.8% of schools with solar panels and dedicated commitment by the state government to sustainable education has paved the way for government schools to adopt solar energy. The state of Jharkhand has made remarkable progress with 7.2% of schools with solar panels. Niti Aayog in its SDG report 2020-21, had put Jharkhand in the aspirant category for SDG 4: Quality Education, having an index score of less than 50. The state's commitment to adopting and scaling solar power in schools shows a proactive approach by the government in providing reliable electricity access and promoting sustainability in education. On the other hand, Chandigarh and Delhi with 67.8% and 28.1% of schools with solar panels, show the importance and commitment by authorities to scale the solarization of schools in these states. The national percentage by all management types is 6.7 percent for adopting solar panels in schools. States that are doing remarkably above national level are Chandigarh (67%), Delhi (28%), Haryana (16%), Ladakh (15%) and Karnataka (12%).

1. Chandigarh

Chandigarh Renewable Energy & Science & Technology Promotion Society (CREST) had set a 'Net Zero Plan' for all government departments in the city. Within this plan, 106 government schools became self-reliant and met all their energy requirements through solar power.[13] According to CREST in 2022, 58 out of 79 private schools have roof-top solar plants.[14] Schools in Chandigarh have adopted solar technology at a large scale, not only to save on electricity bills but also to make students aware of the huge environmental challenges we face. Thereby, making them agents of change of sustainability that benefit their community. The installation of solar panels makes the students comprehend the practical knowledge of solar energy.

2. Delhi

In 2020, under a central government scheme, the Delhi government set up rooftop solar projects in 150 school buildings, to generate 2,000 megawatts (MW) of solar energy by 2025.[15] Under this project, rooftop solar (RTS) developers were recognized via competitive bidding. The Zero-investment Renewable Energy Service Company (RESCO) model, which offers electricity to consumers from renewable energy sources, was taken up. Since the project was implemented under a central government scheme, a quarter of the total project cost was shouldered by the central government upon conclusion. With the help of this scheme, schools were able to save on their electricity bills and were able to utilize the saved money on the development of school infrastructure and to create awareness about renewable energy solutions. According to Antoninis et al. (2023), the percentage of schools with solar panel systems across the country was highest in Chandigarh and Delhi—two of the richest and most urban territories in the country. The Report suggested that this is because PV technology for school electrification was driven by potential capacity for investment and available technology in these two cities.

3. Haryana

To ensure self-sufficiency in schools, the Haryana Government made it compulsory for all private schools to adopt solar systems.[16] As an incentive, the state government gave a grant of Rs. 20,000 per kilowatt to encourage schools to install solar panels. The mandate came into force, due to the high levels of pollution being witnessed in Gurgaon.

During the summer vacations, the solar electricity thus generated would be added to the grid and this record will be maintained through net metering. This will save the electricity bill of the private schools and promote a clean and green environment. A few schools which have installed green technology are Ajanta Public School which has set 265 kw solar panels on the rooftop and in due course will increase it to 500 kw. Suncity World School has installed a 77kw solar plant, producing 8,500 units of electricity per month. On the other hand, DPS Sushant Lok is in the process of setting up a 50kv solar plant in their school.[17]

4. Ladakh

"*Axis Bank in collaboration with 17000 ft Foundation- a non-profit based organization in Ladakh, adopted 108 remote government schools of Ladakh under a 3 year project to improve infrastructure and bring in learning improvement for the children of these schools*"[18]. In 2018, they launched Digi Lab- a project to bring Digital Learning opportunities in 108 schools, powered by Solar. Through this Digital Learning, access to hardware and software were provided to ensure customized e-learning content directly to the students. To provide electricity for Digital Labs in the school, 200 Solar panels and batteries were installed. With the help of these digital labs, the learning abilities of children will improve along with improving their computer literacy. This project shows that with the help of solar technology, digital technology can be made accessible in remote areas of Leh to not only improve the learning outcomes of children but also to customize the digital content to match the local curriculum.

Another example of solarizing in educational institutions is the Student's Educational and Cultural Movement of Ladakh (SECMOL) situated in Leh. SECMOL campus is completely powered by solar energy and entirely run by the students, who are given the complete responsibility to manage the operation for the whole campus (Gupta 2024). The unique feature of this school is that it is a Net Zero Energy Building, i.e., the building is off-grid (which means not dependent on fossil fuel energy). In fact, the Solar panels installed are utilized for sourcing and generating of solar energy and meeting the energy requirements of the entire campus.[19]

5. Karnataka

To improve learning outcomes, state-run Bharat Electronics Ltd (BEL) set up solar-powered smart classrooms in 122 government schools in North Karnataka.[20] This initiative would benefit 13,000 students studying in these schools with smart classrooms equipped with modern technology. Such a medium of teaching will empower teachers to easily explain difficult concepts to students which would lead to better learning and academic performance. BEL has provided the smart-class facilities with a 50-inch LED television, central processing unit (CPU) with accessories, green board and LED lights charged with solar batteries.[21]

Another initiative was taken by Enphase Energy, supported by the Government Education Department, to solarize the Karnataka Public School with a 4-kW rooftop solar photovoltaic (PV) micro-inverter-based hybrid system to provide uninterrupted power supply to the entire school[22] (Thomas, 2022). With the help of this project higher primary classrooms with desktops and projectors have been powered by the rooftop solar system.

VI. Policy Recommendations and Concluding Remarks

The above analysis highlights the growing momentum of solar energy adoption in schools across India, with states like Chandigarh, Delhi, and Haryana leading the way in integrating renewable energy solutions into their educational infrastructures. Solar panel installations not only offer a sustainable and cost-effective means of providing electricity to schools but also serve as an educational tool for fostering awareness about environmental sustainability among students. Furthermore, the synergy between solar energy and digital learning in regions like Ladakh underscores the transformative potential of renewable energy in improving educational outcomes, particularly in remote areas. The intersection of renewable energy and education holds tremendous promise, not only in reducing carbon emissions but also in creating dynamic learning environments, reducing operational costs for educational institutions, and nurturing a new generation of environmentally responsible citizens.

Despite the encouraging progress, substantial gaps remain in rural and underserved regions, where access to electricity is still limited. To bridge this divide, there is a need for more inclusive policies that prioritize solar energy adoption in these areas, alongside incentives

for both private and public schools to embrace renewable energy solutions. Below are the policy recommendations for solar panel electrification in Indian schools:

1. **Expansion of Solar Panel Adoption in Rural and Underserved Areas:** While states like Chandigarh, Delhi, and Haryana have made significant strides in solarizing schools, regions with limited access to electricity, such as Assam, West Bengal, and several rural areas, must be prioritized. Policy initiatives should focus on extending the reach of solar energy to these underserved areas, particularly through targeted subsidies or financing mechanisms to ease the upfront costs of installation.

2. **Incentivizing Public-Private Partnerships (PPPs) for Solar Infrastructure:** The success stories in Delhi and Haryana demonstrate the potential of public-private collaboration. Future policies should encourage more state and local governments to partner with private enterprises through models like the Zero-investment Renewable Energy Service Company (RESCO) model in Delhi. These partnerships can leverage private sector expertise and investment, while ensuring that educational institutions benefit from clean, affordable energy without upfront capital expenditure.

3. **Strengthening State-Level Mandates for Solar Adoption:** States such as Haryana have implemented mandates requiring private schools to adopt solar systems, which should be expanded to include both private and public institutions. For example, Haryana's grant of Rs. 20,000 per kilowatt should be scaled up and expanded to include public schools, especially in regions with acute energy shortages, to incentivize adoption at all levels of the educational system.

4. **Integrating Digital and Solar Technologies for Remote Education:** The example of Ladakh, where solar-powered digital learning tools have been implemented in remote schools, offers a replicable model. Policymakers should explore similar initiatives in other underserved regions, ensuring that solar energy powers not only lighting and basic infrastructure but also digital classrooms and e-learning facilities. Special attention should be paid to customizing digital content to local curricula, as demonstrated in Ladakh's Digi Lab initiative.

5. **Promoting Solar as Part of National Education Infrastructure Standards:** The national government should develop and implement policies that make solar energy a standard part of the educational infrastructure through bodies such as the Ministry of Education and Ministry of New and Renewable Energy. This could include mandating solar panels in new school constructions and offering financial support for retrofitting existing schools with solar energy systems.

6. **Capacity Building and Awareness Programs:** Alongside the technical installation of solar panels, policies should emphasize capacity building. School staff and students should be educated on the benefits of solar energy, energy efficiency, and environmental sustainability. Programs like Chandigarh's focus on student engagement with solar technology can serve as a model for schools nationwide, fostering a generation of students who are aware of environmental challenges and equipped to contribute to solutions.

7. **Monitoring, Evaluation, and Data-Driven Policy Adjustment:** A robust system for monitoring the progress of solarization efforts should be established, utilizing platforms like UDISE to track solar adoption rates by state, school type, and geographic location. Regular evaluation will ensure that the most effective policies are scaled up, while less successful initiatives are reformed. Data-driven decision-making is essential for optimizing investments in solar energy in schools.

With the right policies, investments, and collaboration, India can significantly accelerate the transition towards a cleaner, greener educational future, aligning with its broader sustainability goals. The above discussion serves as a critical framework to understand the progress towards sustainable energy access and improved quality of life, hence making this study an important step towards enhancing equitable and sustainable development of the economy.

Endnotes

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