Status Paper

# A Study on Electricity Consumption Trends at Indira Gandhi National Forest Academy


**Indira Gandhi National Forest Academy**

Dehradun, Uttarakhand

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April 2024

**Indira Gandhi National Forest Academy**
Ministry of Environment, Forest and Climate Change
Post Office New Forest
Dehradun – 248006 (Uttarakhand) India

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# EXECUTIVE SUMMARY


India faces a growing electricity demand due to its expanding population and developmental aspirations. However, the impacts of ever-increasing electricity demand and the need for climate calls for understanding the current status of electricity consumption through the lens of energy efficiency and renewable energy. In this context, this study presents a comprehensive assessment of the current electricity consumption patterns at the Indira Gandhi National Forest Academy (IGNFA). Aligned with the Academy's commitment to sustainability and conservation, the study analyses the electricity consumption data to find potential opportunities for adopting sustainable energy practices.

This study employs a data-driven approach to analyze electricity consumption and corresponding solar energy contribution at IGNFA. The total electricity consumption is found to be 11,31,456 units in 2021, 12,57,981 units in 2022, and 13,65,145 units in 2023, showing a CAGR of 10%. The per capita electricity consumption is estimated to be 2,509 kWh in 2023, with rooftop solar power providing about 10% of total electricity. The study delves deeper, examining consumption trends over the past three years, seasonal variations, and differences across facilities at IGNFA. It also explores the relationship between electricity use and ambient temperature, alongside the monthly variations in solar energy generation.

The analyses shows that the electricity consumption is highest in the winter months of November, December, January, and February, owing to the increased building heating and water heating demands. It is notable that the electricity consumption in monsoon season is higher than the summer and winter seasons in two of the three years because during this season the training schedule of IFS probationers typically comprises only of classroom sessions and study tours are not undertaken. Further, it is observed that the per capita electricity consumption at Executive Hostel is significantly higher than all other premises of IGNFA due to low occupancy and higher maintenance requirement. It is also noted that the solar power share in the electricity consumption of New Hostel premises is about 43% over the 3 years study period because of the 122 kWp high-capacity rooftop solar system, whereas it is only 6% at the Academy Main building because of the 20 kWp low-capacity system. This underscores the potential to increase the adoption of renewable energy by the Academy.

Significant improvements in electricity-use efficiency, and a greater reliance on renewable energy sources is the way ahead to reduce the Academy's Carbon Footprint from electricity consumption for a net-zero future.


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# Abbreviations

| | |
|---|---|
| CEA | Central Electricity Authority |
| FICCI | Federation of Indian Chambers of Commerce and Industry |
| GOI | Government of India |
| IGNFA | Indira Gandhi National Forest Academy |
| kWh | Kilowatt-hour |
| kWp | Kilowatt-peak |
| LiFE | Lifestyle for Environment |
| NDC | Nationally Determined Contributions |
| UNFCCC | United Nations Framework Convention on Climate Change |

Status Paper

# A Study on Electricity Consumption Trends at Indira Gandhi National Forest Academy

## 1.0 Introduction

India is the world's fastest-growing major economy, undergoing a rapid population and economic growth. This translates to rising energy demand, primarily met by fossil fuels like coal, which account for nearly 56% of the country's installed capacity as on 31-01-2024 (data from CEA, Ministry of Power, GOI). Moreover, India's energy demand is expected to double by 2070 as per a latest report by FICCI and Deloitte India released in September 2023. In this context, the country is already experiencing the effects of climate change in terms of heatwaves, floods, and droughts. This highlights the crucial role of managing our energy consumption and reducing our carbon emissions for mitigating the climate change impacts. It also underscores the Government of India's objectives in this direction through various efforts such as the NDC targets relating to energy under the Paris Agreement of UNFCCC and the Mission LiFE mass-movement launched for citizens' behavioural change towards a sustainable and a responsible lifestyle.

The Indira Gandhi National Forest Academy (IGNFA) in Dehradun, Uttarakhand plays a vital role in training the current and future generations of IFS officers. Understanding the environmental impact of the academy's operations is crucial for ensuring that its sustainability practices align with its environment conservation mission. In this backdrop, the authors undertook a study to investigate the electricity consumption patterns and associated Carbon Footprint of the IGNFA.

This study holds significance for several reasons. Firstly, it will provide valuable insights into the consumption patterns and associated environmental impact of an apex training institution in India. Secondly, it shall help to formulate and implement a roadmap towards a sustainable lifestyle in the Academy aligning with its core mission of forest conservation. Thirdly, this study can serve as a model for other institutions seeking to take stock of their electricity consumption and minimize their environmental footprint.

## 2.0 Objectives of the Study

This study aims to achieve the following specific objectives with a purpose to understand the energy usage at IGNFA.

a) Develop baseline data of electricity consumption of IGNFA comprehensively for future use and reference
b) Analyze the electricity consumption patterns
c) Derive quantified insights in electricity consumption using data analytics
d) Estimate Carbon Footprint of the Academy associated from electricity use
e) Develop a roadmap of actionable measures for adopting sustainable energy practices to reduce Carbon Footprint.

## 3.0 Methodological Steps

The methodological steps followed to undertake the study are following.

a) Review literature on management of electricity consumption and Carbon Footprint.
b) Collect data on electricity usage in various sectors, including academic buildings, hostels, residential complex, and common areas, from the IGNFA Office.
c) Data analysis and interpretation for the past few years data.
d) Select and employ appropriate emission factors to translate the electricity consumption data into its equivalent Carbon Footprint.
e) Propose actionable measures based on the findings of the study for reducing the Carbon Footprint.

## 4.0 Data Collection and Cleaning

On preliminary exploration, it was found that the estates of the Academy consume electricity that is supplied by two major sources viz., a) thermal power from the eight UPCL utility connections and b) roof-top solar power installed at two locations. Subsequently, a data collection pro-forma was designed for year-wise and month-wise consumption data collection. The same was submitted to the Estate Officer IGNFA requesting for last 3-5 year data in Kilo-Watt hours (KWh). The request was approved and forwarded to the concerned section in the IGNFA Office, who provided the requested data.

This data, however, was marked with some gaps and technical issues. These include unavailability of data for certain months in some UPCL connections, "zero" data in certain entries in spite of valid bill payments due to metering issue, etc. These issues were then sorted by estimating the missing data using payment amounts, checking respective month's office notes in case of unavailability of bills, etc. Finally, a clean database of 3 years, year- wise, month-wise and utility connection-wise, was compiled, as given below in Tables 1, 2, and 3.

**Electricity Consumption for the year 2021 (in KWh)**

| A | UPCL CONNECTIONS | Connection No | January | February | March | April | May | June | July | August | September | October | November | December |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | IGNFA Guest House, Hari Singh Auditorium, New Hostel Mess Servant Qtrs | 716 | 5720 | 3360 | 2160 | 6357 | 5480 | 5800 | 6560 | 5920 | 5240 | 3840 | 4360 | 11200 |
| 2 | New Hostel A, B, C Block, Tennis Court & Squash Court | 3226 | 16560 | 14120 | 4640 | 3444 | 9120 | 13000 | 1680 | 880 | 880 | 1880 | 7520 | 13240 |
| 3 | New Hostel D, E & F Block | 722 | 6440 | 5800 | 2320 | 2765 | 3680 | 4000 | 160 | 120 | 200 | 520 | 3360 | 6720 |
| 4 | Executive Hostel | 854 | 5550 | 4830 | 4590 | 7396 | 8430 | 4170 | 4260 | 5850 | 6060 | 5640 | 9690 | 7440 |
| 5 | Old Hostel A to E block & Dhobighat | 719 | 10200 | 26440 | 14680 | 8322 | 27120 | 27400 | 25120 | 14080 | 9000 | 7520 | 4640 | 4560 |
| 6 | Swimming Pool | 123978 | | | | | | | | | | | | |
| 7 | Academy Main Building & Library Building | 723 | 37440 | 29440 | 22800 | 24134 | 24134 | 32080 | 37360 | 31440 | 29120 | 39920 | 10160 | 37760 |
| 8 | IGNFA Residential Complex (Litchi Bagh) | 8198 | 23920 | 22000 | 14320 | 17200 | 17280 | 19680 | 18320 | 16160 | 15280 | 22720 | 6800 | 25040 |
| B | **MI SOLAR CONNECTIONS** | | January | February | March | April | May | June | July | August | September | October | November | December |
| 9 | New Hostel B-Block | | 3834 | 2836 | 5144 | 4715 | 4715 | 4476 | 2536 | 2896 | 3482 | 3664 | 3528 | 3274 |
| 10 | New Hostel E-Block | | 4102 | 3494 | 6088 | 3691 | 3691 | 3784 | 2130 | 2444 | 4060 | 4814 | 4230 | 3754 |
| 11 | Academy Main Building | | 2108 | 1568 | 2638 | 2277 | 2277 | 2470 | 1410 | 1640 | 1696 | 1886 | 1862 | 1700 |

*Table 1: Electricity Consumption for the year 2021 (in KWh)*

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Electricity Consumption for the year 2022 (in KWh)** | | | | | | | | | | | | | | |
| **A** | **UPCL CONNECTIONS** | **Connection No** | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| 1 | IGNFA Guest House, Hari Singh Auditorium, New Hostel Mess Servant Qtrs | 716 | 4280 | 4800 | 3200 | 3240 | 4880 | 6360 | 7200 | 5520 | 3320 | 1520 | 3000 | 4600 |
| 2 | New Hostel A, B, C Block, Tennis Court & Squash Court | 3226 | 17160 | 18120 | 3280 | 6520 | 3440 | 8440 | 11440 | 4480 | 6080 | 3480 | 6840 | 11160 |
| 3 | New Hostel D, E & F Block | 722 | 8760 | 9800 | 2960 | 2520 | 1160 | 2440 | 3520 | 1480 | 2400 | 1880 | 2280 | 4960 |
| 4 | Executive Hostel | 854 | 10050 | 7200 | 6630 | 5550 | 6360 | 6720 | 14550 | 12900 | 14370 | 11070 | 9870 | 12510 |
| 5 | Old Hostel A to E block & Dhobighat | 719 | 15040 | 3840 | 4600 | 9560 | 10680 | 11320 | 11880 | 16360 | 6840 | 3560 | 5160 | 31400 |
| 6 | Swimming Pool | 123978 | | | | | 9294 | 8379 | 6522 | 5820 | 7266 | 9255 | 8403 | 12228 |
| 7 | Academy Main Building & Library Building | 723 | 37600 | 30720 | 28720 | 28960 | 32720 | 38960 | 44720 | 37520 | 38240 | 27120 | 22720 | 31280 |
| 8 | IGNFA Residential Complex (Litchi Bagh) | 8198 | 26320 | 18960 | 15120 | 13280 | 17760 | 17280 | 17920 | 16560 | 14640 | 13360 | 18560 | 25760 |
| **B** | **MI SOLAR CONNECTIONS** | | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| 9 | New Hostel B-Block | | 2654 | 3576 | 5214 | 5058 | 5022 | 4854 | 3794 | 3924 | 3870 | 3442 | 4764 | 1960 |
| 10 | New Hostel E-Block | | 3190 | 4772 | 6724 | 6332 | 6034 | 5818 | 4602 | 4812 | 5126 | 4560 | 5558 | 2276 |
| 11 | Academy Main Building | | 1424 | 1970 | 2578 | 2462 | 5372 | 368 | 546 | 1762 | 1832 | 1804 | 2434 | 986 |

*Table 2: Electricity Consumption for the year 2022 (in KWh)*

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Electricity Consumption for the year 2023 (in KWh)** | | | | | | | | | | | | | | |
| **A** | **UPCL CONNECTIONS** | **Connection No** | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| 1 | IGNFA Guest House, Hari Singh Auditorium, New Hostel Mess Servant Qtrs | 716 | 5400 | 3720 | 2080 | 1920 | 2360 | 5120 | 4760 | 6480 | 4600 | 3120 | 3800 | 5280 |
| 2 | New Hostel A, B, C Block, Tennis Court & Squash Court | 3226 | 11240 | 9000 | 7880 | 5520 | 3880 | 7280 | 11120 | 6480 | 1440 | 3840 | 4080 | 24480 |
| 3 | New Hostel D, E & F Block | 722 | 4120 | 3560 | 4240 | 2920 | 1360 | 2120 | 2320 | 960 | | | | |
| 4 | Executive Hostel | 854 | 12690 | 19800 | 7920 | 9210 | 9660 | 19740 | 8190 | 17610 | 22590 | 14400 | 11520 | 27300 |
| 5 | Old Hostel A to E block & Dhobighat | 719 | 52000 | 25920 | 15040 | 12720 | 7680 | 22520 | 18920 | 21520 | 9040 | 5960 | 17400 | 42120 |
| 6 | Swimming Pool | 123978 | 5944 | 9476 | 6920 | 5712 | 6060 | 8024 | 5140 | 6672 | 6552 | 8576 | 11880 | 18884 |
| 7 | Academy Main Building & Library Building | 723 | 36160 | 23840 | 24320 | 23280 | 23200 | 25840 | 30339 | 41331 | 32790 | 29988 | 26388 | 39120 |
| 8 | IGNFA Residential Complex (Litchi Bagh) | 8198 | 18560 | 15680 | 15680 | 15040 | 12320 | 14080 | 16513 | 31840 | 13120 | 11520 | 11440 | 18560 |
| **B** | **MI SOLAR CONNECTIONS** | | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| 9 | New Hostel B-Block | | 4808 | 4554 | 2368 | 5664 | 4688 | 5250 | 3408 | 3734 | 3118 | 3572 | 2736 | 3020 |
| 10 | New Hostel E-Block | | 5728 | 5904 | 2772 | 7342 | 5662 | 6306 | 3664 | 1804 | 3148 | 3408 | 1964 | 1968 |
| 11 | Academy Main Building | | 2402 | 2160 | 868 | 2548 | 1916 | 2198 | 1114 | 1420 | 1308 | 1718 | 876 | 1288 |

*Table 3: Electricity Consumption for the year 2023 (in KWh)*

Following the task of obtaining the above data, the number of persons using the above electricity units during the respective month and year was estimated as given below in Tables 4, 5, and 6. This estimation was made based on the number of IFS probationers in the last three years, IGNFA staff strength (data given by Account Section IGNFA), other training participants at Executive hostel (data given by Caretakers), and the number of residents at Litchi Bagh complex (data given by Caretakers). This data collected from different sources is also compiled in the Table 7 below. All these data tables were analysed for drawing various insights, which are covered in the next section.

| No. of Electricity consumers during 2021 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A UPCL CONNECTIONS** | **Connection No** | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| 1 IGNFA Guest House, Hari Singh Auditorium, New Hostel Mess Servant Qtrs | 716 | 78 | 46 | 30 | 87 | 75 | 79 | 99 | 90 | 79 | 58 | 66 | 170 |
| 2 New Hostel A, B, C Block, Tennis Court & Squash Court | 3226 | 448 | 382 | 125 | 93 | 246 | 351 | 45 | 24 | 24 | 51 | 203 | 358 |
| 3 New Hostel D, E & F Block | 722 | 179 | 161 | 64 | 77 | 102 | 111 | 4 | 3 | 6 | 14 | 93 | 187 |
| 4 Executive Hostel | 854 | 555 | 483 | 459 | 740 | 843 | 417 | 426 | 585 | 606 | 564 | 969 | 744 |
| 5 Old Hostel A to E block & Dhobighat | 719 | 155 | 401 | 222 | 126 | 411 | 415 | 381 | 213 | 136 | 114 | 70 | 69 |
| 6 Swimming Pool | 123978 | | | | | | | | | | | | |
| 7 Academy Main Building & Library Building | 723 | 130 | 102 | 79 | 84 | 84 | 111 | 173 | 146 | 135 | 185 | 47 | 175 |
| 8 IGNFA Residential Complex (Litchi Bagh) | 8198 | 199 | 183 | 119 | 143 | 144 | 164 | 153 | 135 | 127 | 189 | 57 | 209 |
| **B MI SOLAR CONNECTIONS** | | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| 9 New Hostel B-Block | | 53 | 39 | 70 | 65 | 65 | 61 | 38 | 44 | 53 | 56 | 53 | 50 |
| 10 New Hostel E-Block | | 56 | 48 | 83 | 51 | 51 | 52 | 32 | 37 | 62 | 73 | 64 | 57 |
| 11 Academy Main Building | | 7 | 5 | 9 | 8 | 8 | 9 | 7 | 8 | 8 | 9 | 9 | 8 |

*Table 4: No. of Electricity consumers during 2021*

| No. of Electricity consumers during 2022 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A UPCL CONNECTIONS** | **Connection No** | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| 1 IGNFA Guest House, Hari Singh Auditorium, New Hostel Mess Servant Qtrs | 716 | 66 | 66 | 66 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 |
| 2 New Hostel A, B, C Block, Tennis Court & Squash Court | 3226 | 33 | 33 | 33 | 33 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 |
| 3 New Hostel D, E & F Block | 722 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 |
| 4 Executive Hostel | 854 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 5 Old Hostel A to E block & Dhobighat | 719 | 66 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 101 |
| 6 Swimming Pool | 123978 | 1 | 1 | 1 | 1 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 168 |
| 7 Academy Main Building & Library Building | 723 | 226 | 226 | 293 | 293 | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 328 |
| 8 IGNFA Residential Complex (Litchi Bagh) | 8198 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| **B MI SOLAR CONNECTIONS** | | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| 9 New Hostel B-Block | | 66 | 66 | 66 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 |
| 10 New Hostel E-Block | | 66 | 66 | 66 | 66 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 |
| 11 Academy Main Building | | 226 | 226 | 293 | 293 | 227 | 227 | 227 | 227 | 227 | 227 | 227 | 328 |

*Table 5: No. of Electricity consumers during 2022*

| No. of Electricity consumers during 2023 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A UPCL CONNECTIONS** | **Connection No** | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| 1 IGNFA Guest House, Hari Singh Auditorium, New Hostel Mess Servant Qtrs | 716 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 101 | 101 | 101 | 101 |
| 2 New Hostel A, B, C Block, Tennis Court & Squash Court | 3226 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 61 | 61 | 61 | 61 |
| 3 New Hostel D, E & F Block | 722 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 1 | 1 | 1 | 1 |
| 4 Executive Hostel | 854 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 50 | 50 |
| 5 Old Hostel A to E block & Dhobighat | 719 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 101 | 114 | 114 |
| 6 Swimming Pool | 123978 | 168 | 168 | 168 | 168 | 168 | 168 | 168 | 168 | 101 | 101 | 101 | 101 |
| 7 Academy Main Building & Library Building | 723 | 338 | 338 | 338 | 338 | 338 | 338 | 338 | 338 | 271 | 271 | 452 | 452 |
| 8 IGNFA Residential Complex (Litchi Bagh) | 8198 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| **B MI SOLAR CONNECTIONS** | | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** | **December** |
| 9 New Hostel B-Block | | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 61 | 61 | 61 | 61 |
| 10 New Hostel E-Block | | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 61 | 61 | 61 | 61 |
| 11 Academy Main Building | | 338 | 338 | 338 | 338 | 338 | 338 | 338 | 338 | 271 | 271 | 452 | 452 |

*Table 6: No. of Electricity consumers during 2021*

| S No | Item | Numbers of Consumers |
|---|---|---|
| 1 | IFS 2019-20 batch | 73 |
| 2 | IFS 2020-21 batch | 66 |
| 3 | IFS 2021-23 batch | 67 |
| 4 | IFS 2022-24 batch | 101 |
| 5 | IFS 2023-25 batch | 114 |
| 6 | IGNFA staff 2021 | 142 |
| 7 | IGNFA staff 2022 | 152 |
| 8 | IGNFA staff 2023 | 162 |
| 9 | Executive Hostel for Other Trainings (Equivalent consumers for the year) | 10 |
| 10 | Litchi Bagh complex | 120 |

*Table 7: Source Data compiled for estimating Electricity Consumers over the three years*

# 5.0 Data Analysis

## 5.1 Per Capita Electricity Consumption

The total electricity consumption of IGNFA was 11,31,456 units in 2021, 12,57,981 units in 2022, and 13,65,145 units in 2023, showing a CAGR of 10%. Now, the per capita electricity consumption represents the annual electricity units consumed by an average person at IGNFA. This was computed by dividing the total units of consumption by the Academy in a year by the total number of persons consuming it in that year. The data computed is given in the Table 8 and shown in Figure 1 below, with a visual comparison to the world and India averages. It is found that the average electricity consumption per capita in IGNFA is little over 2.5 times the national average and slightly less than the global average. This may partly be attributed to the higher standards of living in the Academy due to the available infrastructure and facilities. The overall consumption of the Academy has also been examined in two parts – viz., a) FRI campus and b) Litchi Bagh Residential Complex. The results of the same are presented in the Table. It is evident that the consumption in FRI is much higher than Litchi Bagh Residential Complex and is a little over the World average. It is understood that this difference between the two premises exists because of their difference in institutional vis-à-vis domestic energy demands.

From Table 8, it is evident that the per capita consumption from 2021 to 2022 shows an increase of 12% whereas that from 2022 to 2023 shows a decrease of 18%. On investigating this matter, it is found that the said increase in consumption is due to the swimming pool operations that commenced in May 2022 and attributed majorly to 67 IFS probationers' of 2021 batch, thereby soaring up the per capita figures. Whereas the said decrease in consumption is because all the consumption units, especially the ones corresponding to fixed consumption, have been attributed to 168 IFS probationers of 2021 and 2022 batches, thereby reducing the per capita figure.

| S No | Year | IGNFA | IGNFA - FRI | IGNFA - Litchibagh | Growth (Y-o-Y) | World Average | India Average |
|---|---|---|---|---|---|---|---|
| 1 | 2021 | 2733 | 3643 | 1823 | | 3373 | 1133 |
| 2 | 2022 | 3053 | 4309 | 1796 | 12% | 3541 | 1218 |
| 3 | 2023 | 2509 | 3398 | 1620 | -18% | 3594 | 1311 |

*Table 8: Per Capita Electricity Consumption of IGNFA (in KWh)*

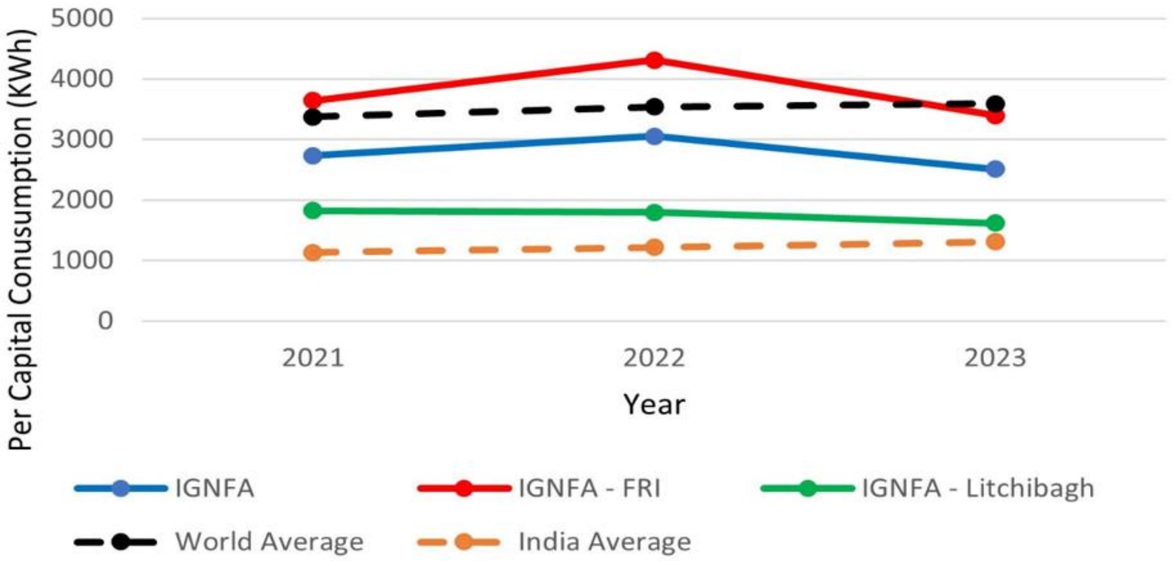


*Figure 1: Per Capita Electricity Consumption trend over 3 years*

## 5.2 Contribution of Solar Energy

Apart from the UPCL electricity connections, the current electricity demand is also met from roof-top solar power installed at two locations by M/s MI Solar. This was executed by a Power Purchase Agreement undertaken by IGNFA and MI Solar for a 25-year period in June 2016. The Agreement was signed for 140 kWp Solar PV Power System, but it is learnt that only 112 kWp capacity only was installed. On analysis of the solar electricity units consumed across the two locations for the past three years, it was found to comprise 10% of the Academy's total consumption. This data is given in the Table 9 and pie chart (Figure 2) below.

| S No | Year | Renewable Energy | Non-Renewable Energy |
|---|---|---|---|
| 1 | 2021 | 10% | 90% |
| 2 | 2022 | 10% | 90% |
| 3 | 2023 | 9% | 91% |

*Table 9: Share of Solar Energy in Total Energy Consumption over 3 years*

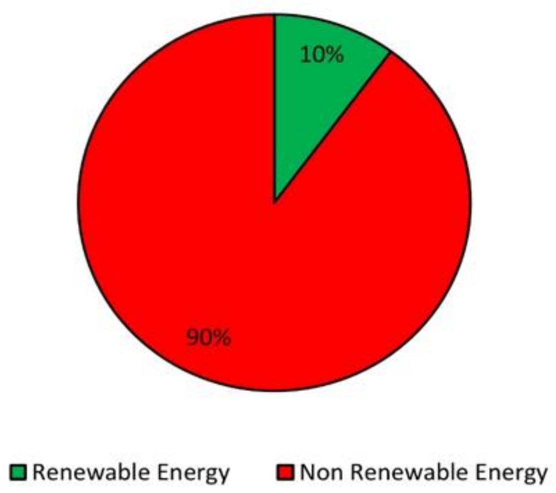


*Figure 2: Share of Solar Energy in Total Energy Consumption*

The solar power data was further analysed to understand the location-wise share of solar energy in the respective energy consumption. It is found that the renewable energy contribution at the New Hostel premises is over 40% while at the Academy Main Building is only 6%, as shown in Table 11 below. The year-wise data pertaining to this is given in the table and charts below. The reason for this difference in contribution is due to the fact that the solar panels installed on New Hostel has a capacity of 102 kWp (of which 60 kWp is now shifted to Old Hostel) whereas that of Academy Main Building is 20 kWp only. Thus, it is also noted that the cumulative generation at New Hostel is about 4.6 times to that at the Academy Main Building over the 3 years, as shown in the Table 10 below.

| S No | Solar Installation Location | Capacity (KWp) | Units in last 3 years (KWh) | Share (%) |
|---|---|---|---|---|
| 1 | Academy Main Building | 20 | 66,886 | 18% |
| 2 | New Hostel | 102 | 2,95,908 | 82% |
| | **Total** | **122** | **3,62,794** | |

*Table 10: Solar Power Capacity and Consumption of IGNFA*

| S No | Location | RE 2021 | NRE 2021 | % RE 2021 | RE 2022 | NRE 2022 | % RE 2022 | RE 2023 | NRE 2023 | % RE 2023 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Academy Main Building | 23532 | 355788 | 6% | 23538 | 399280 | 6% | 19816 | 356596 | 5% |
| 2 | New Hostel | 91382 | 123049 | 43% | 107936 | 144600 | 43% | 96590 | 117840 | 45% |
| * RE = Renewable Energy (in KWh) and NRE = Non-Renewable Energy (in KWh) | | | | | | | | | | |

*Table 11: Energy Consumption mix at IGNFA*

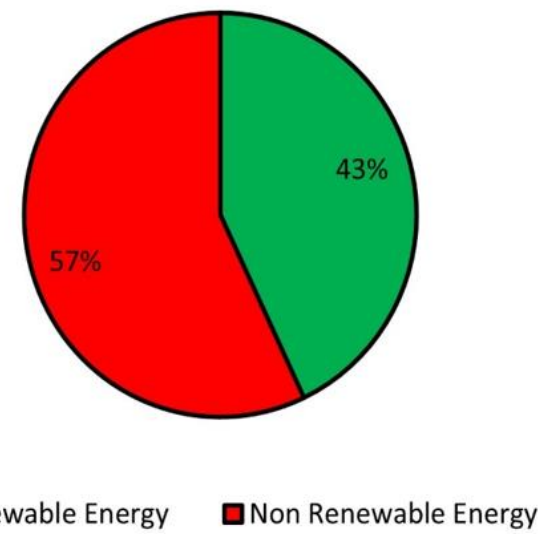


*Figure 3: Share of Solar Energy in Total Consumption at New Hostel during last 3 years*

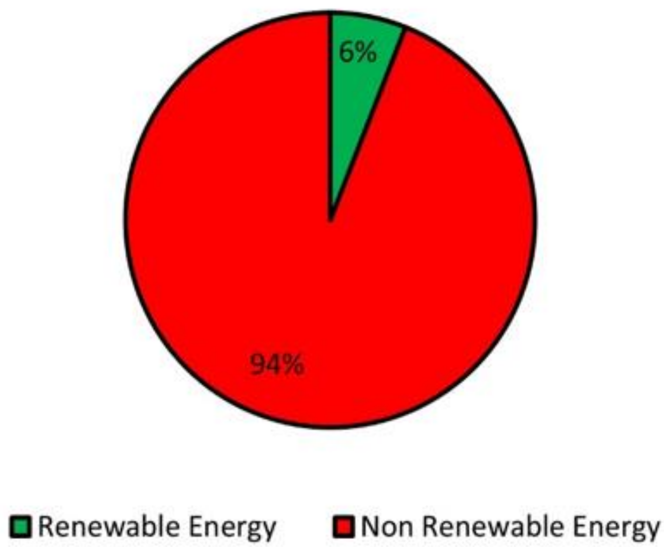

*Figure 4: Share of Solar Energy in Total Consumption at Academy Main Building during last 3 years*

## 5.3 Seasonal Per Capita Electricity Consumption

Electricity consumption in a place like Dehradun, and everywhere in general, has a correlation to the season. This was investigated by computing the monthly per capita electricity consumption in different seasons. It is found that the winter season has higher consumption compared to the other two seasons due to increased building and water heating requirements during the long winters. Also, the monsoon season is comparatively higher because both the IFS probationers' batches are present in the Academy, unlike in other seasons when study tours are undertaken. Thus, this increases the total consumption and leads to a higher per capita consumption. The same is shown in Table 12 and Figure 5 below.

| S No | Year | Summer | Winter | Monsoon |
|---|---|---|---|---|
| 1 | 2021 | 219 | 263 | 228 |
| 2 | 2022 | 238 | 256 | 283 |
| 3 | 2023 | 180 | 222 | 235 |

*Table 12: Monthly Per Capita Electricity Consumption in different Seasons (in KWh)*

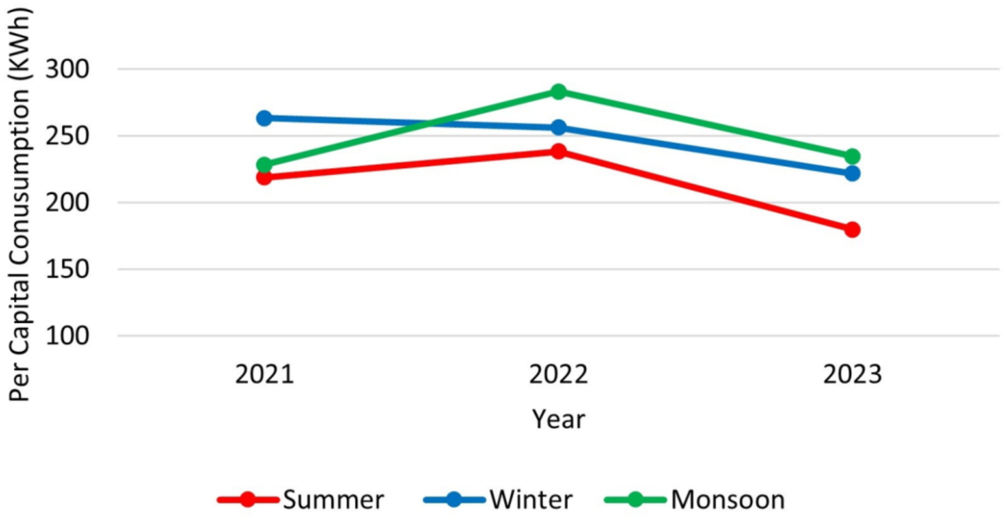


*Figure 5: Yearwise and Season-wise variation in Electricity Consumption of IGNFA*

## 5.4 Location wise Electricity Consumption

Within the Academy, the electricity consumption and its use efficiency vary across premises due to factors like annual occupancy, fixed vis-a-vis variable levels of consumption due to operation of infrastructure and common places, etc. Thus, a location wise analysis is done, and the findings are given in the Table 13 and Figure 6 below. It is found that the highest consumption occurs at Executive hostel, followed by New hostel, and other premises. The Executive hostel consumption is disproportionately high compared to all other premises because its occupancy level across the year is quite low and also its maintenance requires higher electricity consumption. The chart (Figure 6) below depicts this visually.

| S No | Consumption Location | 2021 | 2022 | 2023 |
|---|---|---|---|---|
| 1 | IGNFA Guest House, Hari Singh Auditorium, New Hostel Mess Servant Qtrs, | 958 | 778 | 642 |
| 2 | New Hostel A, B, C Block, Tennis Court & Squash Court, New Hostel D, E & F Block | 4664 | 5951 | 4520 |
| 3 | Executive Hostel | 7391 | 11778 | 14957 |
| 4 | Old Hostel A to E block & Dhobighat | 2713 | 1790 | 2416 |
| 5 | Swimming Pool | | 893 | 775 |
| 6 | Academy Main Building & Library Building | 1541 | 1758 | 1052 |
| 7 | IGNFA Residential Complex (Litchi Bagh) | 875 | 862 | 777 |

*Table 13: Per Capita Electricity Consumption in different Premises of IGNFA (in KWh)*

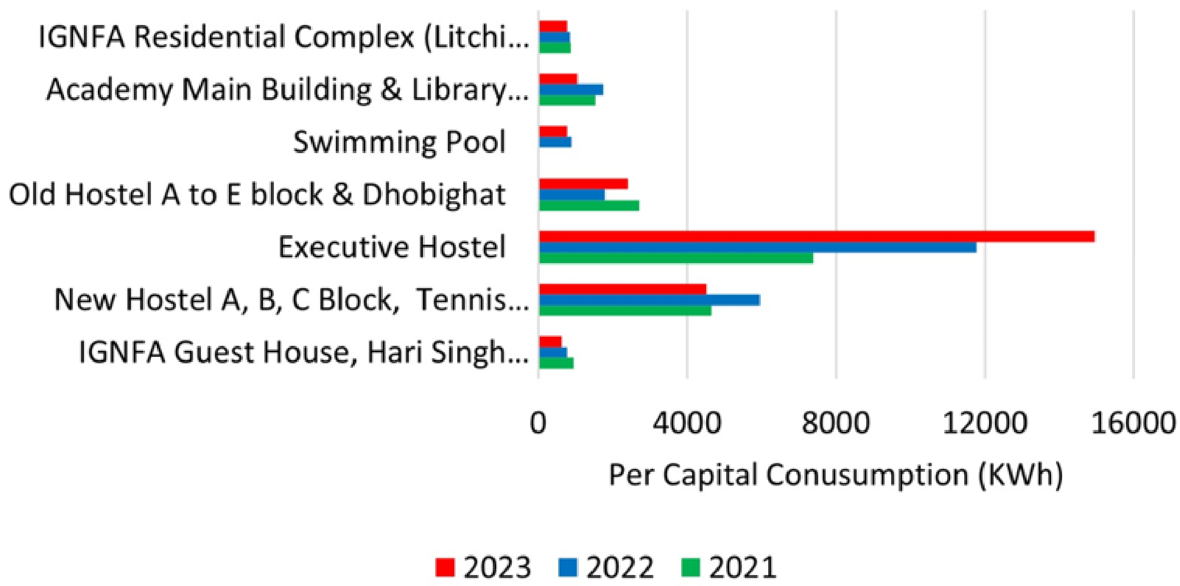


*Figure 6: Per capita Electricity Consumption across various premises of IGNFA*

## 5.5 Electricity Consumption Vs. Monthly Average Temperature

A further investigation into the seasonal variation was done by looking at the annual per capita consumption vis-a-vis the average temperature of the place, on a monthly basis. The findings are shown in Figure 7 and Table 14 below. It is again found that consumption peaked during the core winter months in Dehradun, i.e., December, January and February. This insight can help us to devise a strategic roadmap that targets to minimise the electricity consumption in these peak months and reduce the operational costs of the Academy.

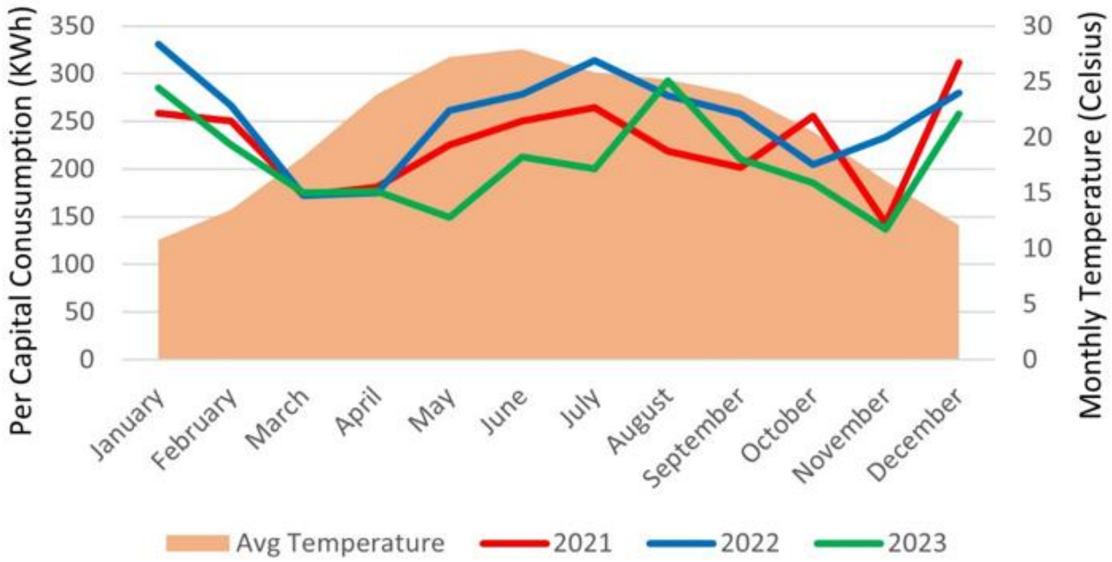


*Figure 7: Monthly per capita electricity consumption vis-à-vis monthly average temperature of Dehradun*

| S No | Month | 2021 | 2022 | 2023 | Average Temperature |
|---|---|---|---|---|---|
| 1 | January | 259 | 331 | 285 | 10.8 |
| 2 | February | 251 | 267 | 225 | 13.5 |
| 3 | March | 172 | 172 | 175 | 18.3 |
| 4 | April | 181 | 175 | 176 | 23.9 |
| 5 | May | 225 | 261 | 150 | 27.2 |
| 6 | June | 250 | 278 | 213 | 27.9 |
| 7 | July | 264 | 314 | 200 | 25.8 |
| 8 | August | 218 | 277 | 292 | 25.2 |
| 9 | September | 202 | 258 | 211 | 23.9 |
| 10 | October | 256 | 205 | 186 | 20.5 |
| 11 | November | 143 | 234 | 137 | 16.1 |
| 12 | December | 312 | 280 | 258 | 12.1 |

*Table 14: Monthly Per Capita Electricity Consumption (KWh) and Monthly Average Temperature (Celsius) of Dehradun*

## 5.6 Monthly Solar Electricity Generation

The solar energy systems are known to have a limitation of providing reliable electricity in times of unfavourable weather conditions. Thus, the solar data was analysed to investigate this matter in the installed rooftop solar system. The monthly average solar power consumption over the 12 months of the last three years is shown in Figure 8 and Table 15 below. This data was obtained from the main metering system of the rooftop solar power plant. It is found that the solar power generation is higher in the clear sky months like March, April, May and June, whereas it is lower during the monsoon and the winter months. This insight shall help the Management to plan appropriate grid-based and battery-based solar systems in future.

| S No | Month | Average | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|
| 1 | January | 10083 | 10044 | 7268 | 12938 |
| 2 | February | 10278 | 7898 | 10318 | 12618 |
| 3 | March | 11465 | 13870 | 14516 | 6008 |
| 4 | April | 13363 | 10683 | 13852 | 15554 |
| 5 | May | 13126 | 10683 | 16428 | 12266 |
| 6 | June | 11841 | 10730 | 11040 | 13754 |
| 7 | July | 7735 | 6076 | 8942 | 8186 |
| 8 | August | 8145 | 6980 | 10498 | 6958 |
| 9 | September | 9213 | 9238 | 10828 | 7574 |
| 10 | October | 9623 | 10364 | 9806 | 8698 |
| 11 | November | 9317 | 9620 | 12756 | 5576 |
| 12 | December | 6742 | 8728 | 5222 | 6276 |

*Table 15: Monthly Solar Power Generation (in KWh)*

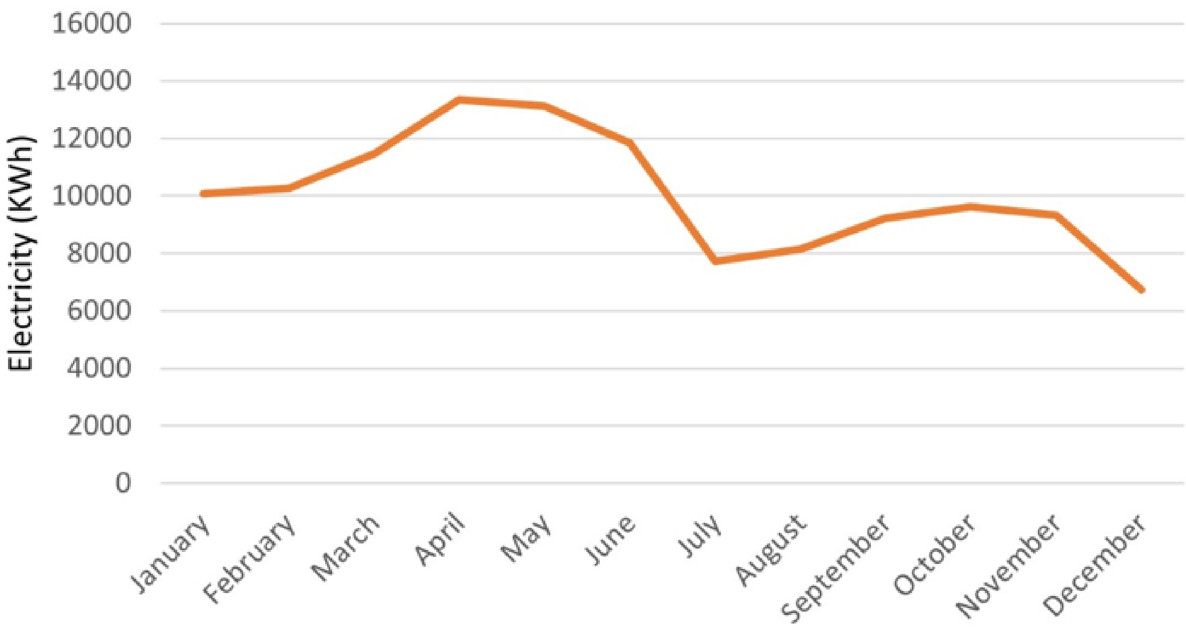


*Figure 8: Monthly variation in Solar Power Consumption of IGNFA over last 3 years*

### 5.7 Carbon Footprint from Electricity

The per capita Carbon Footprint of IGNFA associated to electricity use is computed using the carbon emissions multiplication factor. The multiplication factor was applied only to the electricity consumption from UPCL connections and solar consumption was excluded for this calculation. This provides a clear picture of the IGNFA's contribution to greenhouse gas emissions, specifically focusing on carbon dioxide ($CO_2$) generated from electricity use. The following formula was used:

Consumption (in KWh/Yr) X 0.85 (Emission Factor) = Carbon Footprint in (Kg of $CO_2$)

The per capita Carbon Footprint is found to be 2.12 tonnes of $CO_2$ per annum. It is important to note that this is the footprint arising only out of electricity consumption and typically comprises about 35-40% of the total Carbon Footprint. The per capita world average Carbon Footprint is 4.66 tonnes and India's average is 1.91 tonnes.

## 6.0 Roadmap for Reducing Carbon Footprint

The findings of data analysis from section 5 point out the scope for improvement in electricity consumption and reducing the Carbon Footprint. This includes measures for reducing electricity consumption in the winter months, improving the per capita electricity use efficiency at facilities like Executive Hostel, and tapping the potential of rooftop solar power to its fullest. In this context, the following recommendations for energy efficiency, reducing energy demand, and expansion of rooftop solar power capacity are given below.

### 6.1 Recommendations for Energy Efficiency

#### 6.1.1 Sensor-based Lighting Control Systems

Sensor-based lighting control systems use sensors to automatically turn lights on and off or adjust their brightness. This leads to significant energy savings and improved convenience. Some examples of sensor-based lighting control systems are Philips Hue Motion Sensor, Schneider Electric Occupancy Sensor, and Legrand Daylight Sensor.

**Types of Sensors:**

a) **Occupancy Sensors (Passive Infrared - PIR):** Detect heat signatures of people to turn lights on/off in hallways, restrooms, etc.
b) **Light Sensors (Photocells):** Measure ambient light for daylight harvesting, dimming electric lights when there's sufficient daylight.

**Benefits:**

a) **Energy Savings:** Lights are only on when needed, reducing electricity consumption.
b) **Cost Savings:** Lower electricity bills.
c) **Convenience:** Automatic operation provides a hands-free experience.
d) **Improved Bulb Life:** Reduced on/off cycles extend bulb life.

**Potential Deployment Areas in Academy premises:** Conference rooms, Hallways, Hostel lounges, Auditoriums, Classrooms, Officers' Mess, Washrooms, Parking lot etc.

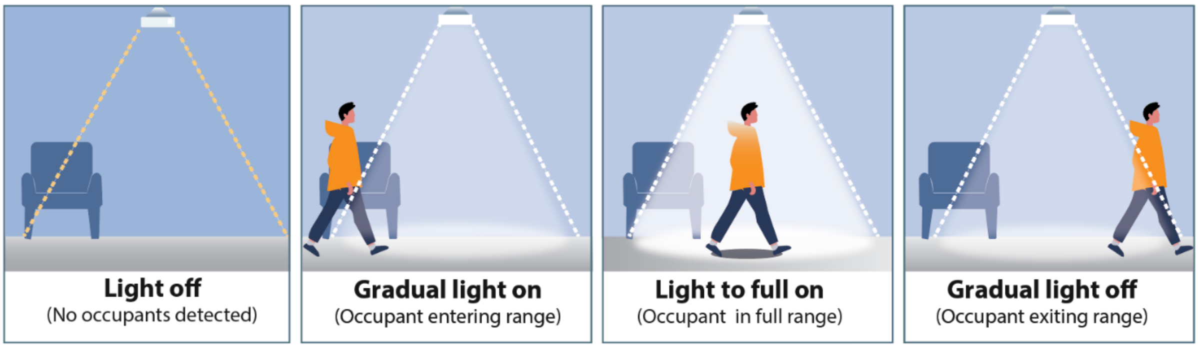


*Figure 9: Illustration of Occupancy Sensors (Copyright © asmag.com)*

### 6.1.2 Upgradation of Appliances

It is noted that the building heating and water heating demand in the winter months leads to a significant hike in energy consumption. Thus, the following recommendations are made to address this issue:

a) **Upgrading air conditioners and water heaters** to 5-star rated products can be helpful to attain better energy efficiency. This has been done in many facilities of the Academy, yet there is scope in some places for this intervention, like the older geysers in the hostel blocks, etc.
b) **Centralised HVAC systems** such as variable refrigerant flow (VRF) systems, high efficiency heat pump systems, etc. may be planned, especially in the upcoming facilities of the Academy. These systems offer several benefits for buildings compared to individual room units such as improved efficiency, even temperature distribution, and easier maintenance.
c) **Solar water heaters** can also be installed in old, new and executive hostel blocks.

### 6.1.3 Smart Metering Systems

Smart meters are a next-generation upgrade to traditional electricity meters. These are advanced devices that measure and record electricity consumption in real-time, providing detailed data on energy usage. Smart Metering systems typically include smart electricity meters equipped with communication capabilities, allowing for remote monitoring and management of energy consumption. Smart metering systems enable utilities and consumers to better understand and manage electricity usage, leading to improved energy efficiency and cost savings.

The Government of India is actively promoting smart meter deployment with a national program aiming for large-scale adoption. Smart meters are a key component of a "smart grid" that allows for better management of the electricity grid and integration of renewable energy sources.

**Function:**

- **a)** Track electricity consumption in real-time.
- **b)** Communicate data wirelessly to a central system.
- **c)** Enable remote meter reading, eliminating manual meter checks.

**Potential Deployment Areas in Academy premises:** There are eight UPCL meters in the Academy. All the meters may be upgraded to smart meters. Some companies that supply smart meters in India are Anvil Cables, Apraava Energy, BCITS, EESL, IPCL, Genus, GMR Infra, HPL, HPMS, India Power Corporation, and IntelliSmart.

## 6.2 Recommendations for Reducing Energy Demand

### 6.2.1 Passive Solar Architecture

Passive solar architecture is a design approach that utilizes the sun's energy for heating and cooling a building naturally, without relying on mechanical or electrical systems. The core principles are:

- **a)** **Harnessing Sunlight:** Large south-facing windows (in the northern hemisphere) allow sunlight to enter the building during winter.
- **b)** **Thermal Mass:** Materials like concrete, brick, or water absorb and store solar heat, releasing it slowly to maintain warmth at night.
- **c)** **Insulation:** Proper insulation throughout the building envelope (walls, roof, and floor) minimizes heat loss in winter and heat gain in summer.
- **d)** **Ventilation:** Strategically placed windows and vents promote natural air circulation for cooling in summer.

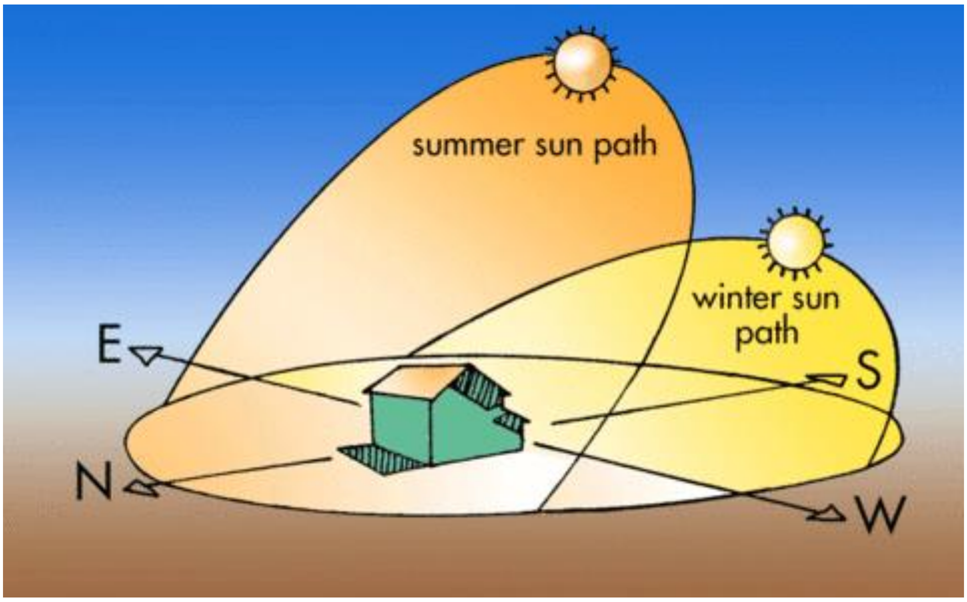


*Figure 10: Movement of Sun in Northern Hemisphere (Copyright © buildinggreen.com)*

**Potential Applications in Academy:**

- **a)** Provision of large south facing windows in all academy buildings for passive solar heating.
- **b)** Provision of Glazed Façades, roof openings and clerestories in buildings planned for/under construction, as shown in Figure 11.

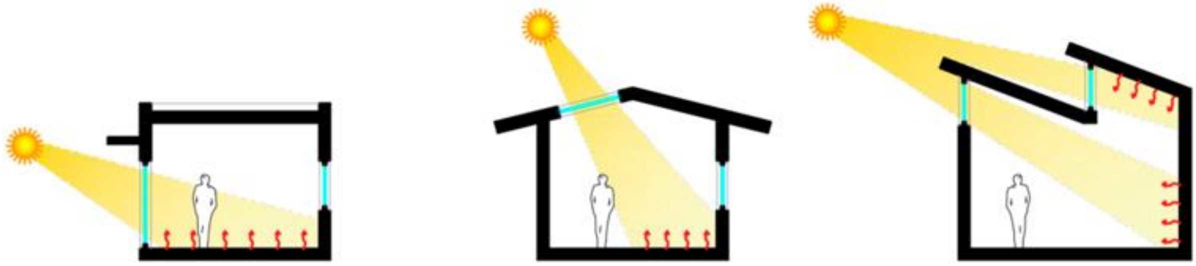

*Figure 11: Direct Solar Heating through i. glazed facades, ii. roof openings, and iii. Clerestories, from left to right (Toroxel and Silva, 2024)*

**c)** Provision of Indirect Solar heating techniques like:

**i.** High Thermal Inertia Envelope can be considered for buildings which stores the heat obtained from solar radiation during the day and release it at night, as shown in Figure 12.

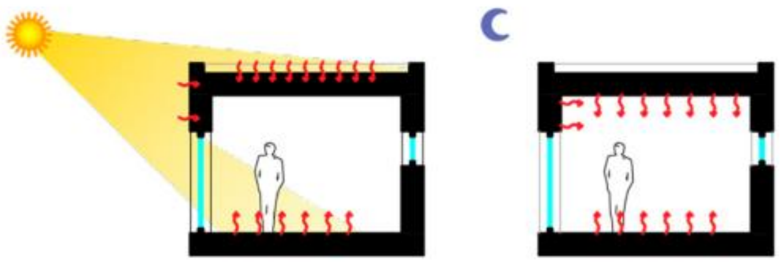

*Figure 12: High Thermal Inertia Envelope (Toroxel and Silva, 2024)*

**ii.** Water tank roofs may be installed to increase thermal inertia of the roof and act as a heat storage element in winters, and for cooling effect in summers, as shown in Figure 13.

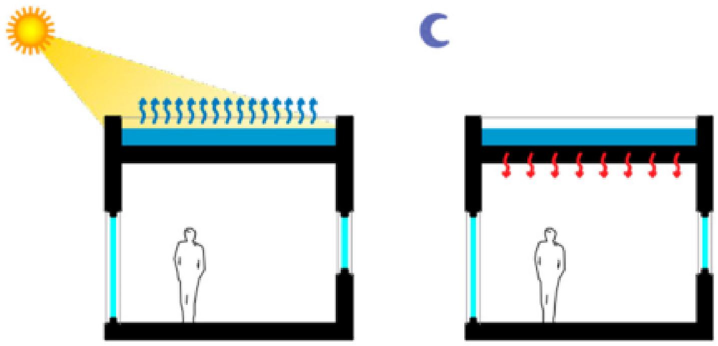

*Figure 13: Water tank roofs (Toroxel and Silva, 2024)*

**iii.** Trombe walls which absorbs solar gains through its glazed façade and stores it as thermal energy in the partition wall with the adjacent room. The wall is typically massive and entirely opaque. Such technologies were learned during the authors' visit to Himalayan Institute of Alternatives, Ladakh (HIAL). Adequate care like shading or curtaining may be employed in summers to avoid heating from sunlight.

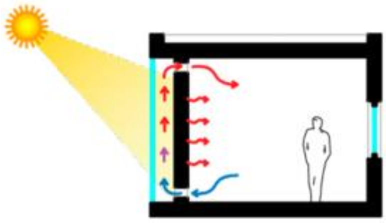

*Figure 14: Trombe Wall (Toroxel and Silva, 2024)*

**d)** The following building materials which have high thermal mass properties are recommended to be used in passive solar architecture – viz., Water, Concrete, Sandstone, compressed Adobe, and Rammed earth.

## 6.3 Recommendations for Increasing Renewable Energy Adoption

The academy has solar panels installed in New Hostel and the Main Building. Recently, the solar panels of 'E' block of New Hostel were shifted to Old Hostel considering the New hostel construction work. The overall contribution of the Renewable energy to the energy consumption mix is 10%. Whereas the contribution of the same in the New Hostel is found to be as high as 43%. This highlights the potential for increasing the renewable energy share in overall energy consumption to at least 40-50% by undertaking necessary solar power installations.

Hence it is recommended to expand the installed solar power capacity across all facilities of the Academy subject to feasibility. This will be in line with the Government of India's push towards rooftop solar power, and contribute towards achieving India's Net Zero goals.

# 7.0 Conclusion

Understanding the current state of electricity consumption is an essential first step for any institution, like IGNFA, striving towards sustainability. This status paper has presented a comprehensive analysis of IGNFA's electricity usage, including per capita consumption trends, renewable energy contribution, variations across months and locations, and the associated Carbon Footprint. This data-driven approach provided a crucial foundation for developing a strategic roadmap for adoption of sustainable energy practices at IGNFA. The findings of this paper highlight the need for initiatives towards enhancing energy efficiency, and exploring opportunities for increased renewable energy integration. Various recommendations in this regard are proposed for adoption that contribute to enhance the energy-use efficiency and reduce Carbon Footprint. Undertaking such interventions, IGNFA can be a model institution committed to environmental conservation and a sustainable future.


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# NOTES:


Indira Gandhi National Forest Academy, Dehradun, is the Staff College for the Indian Forest Service and is the apex institution for the forestry training vertical in the country. The primary mandate of the Academy is to impart training and skills to the policy level senior and the field cadre of professional foresters and other civil and military services thereby facilitate them to develop competencies in governance, administration and management functions related to the country's forest and wildlife resources and associated environmental ecological and economic matters. As a premier central training institute (CTI) in the forestry sector, the academy is also called upon to share the national-level responsibilities for the collation and dissemination of knowledge resources and research related to training and building up of the capacity and competency of human resources in the country.

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