Electrical Load Calculations Mechanical Engineering Department (CEP)

Subject: Power Plants

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Contents

1. Introduction

This Document aims to provide a thorough electric load analysis for the Mechanical Engineering department of the university. It helps in understanding the energy consumption patterns, identifying potential areas for energy savings, and planning for future energy needs. The Mechanical Engineering department, houses a wide range of electrical equipment including lighting fixtures, fans, projectors, computing devices, air conditioners, and other office equipment. Each of these components contributes to the overall electric load of the building, and their usage patterns vary throughout the day. This report provides a detailed breakdown of the power consumption of each type of equipment, taking into account their wattage, usage hours, and relevant factors such as diversity and power factors.

By systematically calculating the daily and monthly electric load, this analysis aims to provide a clear understanding of the building's energy requirements. The results of this study will be instrumental for the university's facility management team to optimize energy usage, improve sustainability practices, and ensure the electrical infrastructure meets current and future demands efficiently.

2. Data collection and required parameters

In order to calculate the electric load of the building, we will need detailed information about the various electrical components and their usage within the building. Here are the key requirements and steps to calculate the load:

- Electrical Appliances and Equipment
- HVAC (Heating, Ventilation, and Air Conditioning)
- Lighting
- Usage Patterns and equipment specifications

Equipment	Quantity	Wattage per Unit	Usage Hours (per day)	Usage Factor	Diversity Factor
LED Lights	233	15W	8 hours	1	0.9
Tube Lights	74	35W	8 hours	1	0.9
Ceiling Fans	150	75W	8 hours	1	0.9
Wall Bracket Fans	7	55W	8 hours	1	0.9
Projectors	4	50W	4 hours	0.5	0.8
CCTV Cameras	12	10W	8 hours	1	1
Water Coolers	2	500W	8 hours	1	0.8
Microwave Oven	1	1200W	1 hour	0.125	0.5
Office PCs	14	250W	8 hours	0.8	0.9
Office Photocopiers	2	800W	1 hour	0.125	0.5
Office Printers	3	50W	1 hour	0.125	0.5
Air Conditioners (1 ton)	16	1500W	8 hours	1	0.8

3. Methodology

3.1. **Equipment listing and categorization:** Categorize all electrical loads into lighting, HVAC, appliances, and miscellaneous

3.2. **Calculate Individual Loads**: For each category, calculate the total power consumption.

$$Total\ Load = Number\ of\ Units \times Power\ Rating \times Operating\ Hours$$

3.3. **Sum the Loads:** Sum up the loads for each category to get the total connected load.

3.4. **Apply Diversity Factor**: Apply a diversity factor to account for the fact that not all equipment operates at full load simultaneously. The diversity factor is typically less than 1 and varies depending on the type of building and usage patterns.

3.5. **Calculate monthly load:** To find the monthly load sum up the daily individual loads of each equipment and then multiply with the number of operating days in a month.

4. Calculation of Daily Load:

First, calculate the daily load for each type of equipment, using;

$$Daily\ Load\ (Wh) = Quantity \times Wattage \times Usage\ Hours \times Usage\ Factor \times Diversity\ Factor$$

- **LED Lights**:

$$Daily\ load\ =\ 233 \times 15 \times 8 \times 1 \times 0.9 = 25164\ Wh$$

- **Tube Lights:**

$$Daily\ load\ =\ 74 \times 35 \times 8 \times 1 \times 0.9 = 18648\ Wh$$

- **Ceiling Fans**:

$$Daily\ laod\ =\ 150 \times 75 \times 8 \times 1 \times 0.9 = 81000\ Wh$$

- **Wall Bracket Fans**:

$$Daily\ load\ =\ 7 \times 55 \times 8 \times 1 \times 0.9 = 2772\ Wh$$

- **Projectors**:

$$Daily\ load\ =\ 4 \times 50 \times 4 \times 0.5 \times 0.8 = 320\ Wh$$

- **CCTV Cameras:**

$$Daily\ load\ =\ 12 \times 10 \times 8 \times 1 \times 1 = 960\ Wh$$

- **Water Coolers:**

$$Daily\ load\ =\ 2 \times 500 \times 8 \times 1 \times 0.8 = 6400\ Wh$$

- **Microwave Oven**:

$$Daily\ load\ =\ \ 1 \times 1200 \times 1 \times 0.125 \times 0.5 = 75\ Wh$$

- **Office PCs**:

$$Daily\ load\ =\ 14\times 250 \times 8 \times 0.8 \times 0.9 = 20160\ Wh$$

- **Office Photocopiers**:

$$Daily\ load = \ 2 \times 800 \times 1 \times 0.125 \times 0.5 = 100\ Wh$$

- **Office Printers**:

$$Daily\ load\ =\ 3 \times 50 \times 1 \times 0.125 \times 0.5 = 9.375\ Wh$$

- **Air Conditioners (1 ton):**

$$Daily\ load\ =\ 16 \times 1500 \times 8 \times 1 \times 0.8 = 153600\ Wh$$

Total Daily Load:

$$25164 + 18648 + 81000 + 2772 + 320 + 960 + 6400 + 75 + 20160 + 100 + 9.375 + 153600 = 309208.375\ Wh/day$$

Convert to kWh:

$$309208.375\ Wh/day \div 1000 = 309.2083\ \boldsymbol{kWh/day}$$

5. Monthly Load

University operates for approximately 22 days in a month (excluding weekends).

$$Monthly\ Load = 309.2083\ kWh/day \times 22\ days = 6802.58425\ \boldsymbol{kWh/month}$$

6. Monthly Tariff for calculated load

Based on the information gathered from the AJK Electricity Department's official website, here are the relevant tariffs applicable to the Bussiness block the university in Mirpur, Azad Kashmir:

6.1. Tariff Categories:

General Services (Applicable to Educational Institutions):

- **Fixed Charges**: Rs. 29.81 per kW per month
- **Variable Charges**: Rs. 29.81 per kWh

6.2. Calculation of Monthly Cost:

Given the previously calculated monthly load of 6802.58425 kWh, the cost calculation can be divided into two parts: fixed charges and variable charges.

Fixed Charges:

The connected load is based on the total wattage of all equipment in use.

$$Total\ wattage\ = \sum(Quantity \times Wattage\ per\ Unit$$

$$(Total\ wattage\ of\ all\ equipment)\text{: } 309208.375\ W\ (309.208kW)$$

$$Fixed\ charges\ for\ connected\ load\text{: } 309.208\ kW \times 29.81\ Rs/kW = 9217.4905\ Rs/month$$

Variable Charges:

The variable charges are based on the energy consumption (kWh).

$$Monthly\ energy\ consumption\text{: } 6802.5842\ kWh$$

Variable charges: 6802.5842 kWh×29.81 Rs/kWh=202785.035 Rs/month

$$Total\ Monthly\ Cost = \ Fixed\ Charges\ +\ Variable\ Charges$$

$$\boldsymbol{Total\ Monthly\ Cost} = 9217.4905\ \boldsymbol{Rs} + 6802.5842\ \text{Rs}\ = \boldsymbol{131352.67\ Rs/month}$$

7. Mechanical Engineering Department

Equipment	Quantity	Wattage (W)	Total Wattage (W)
LED Lights	233	15	3495
Tube Lights	74	35	2590
Ceiling Fans	150	75	11250
Wall Bracket Fans	6	55	330
Projectors	4	50	200
CCTV Cameras	12	10	120
Water Coolers	3	400*	1,200
Office PCs	14	300*	4,200
Office Photocopier	2	800	1600
Office Printers	3	250*	750
AC (1 ton each)	16	1,200*	19200

7.1.Daily and Monthly Load Calculations

$$Daily\ Load\ (Wh) = Total\ Wattage\ (W) \times Hours/Day$$

$$Monthly\ Load\ (Wh) = Daily\ Load\ (Wh) \times Operational\ Days$$

Usage factors

Usage factors for equipment that are not in continuous use:

- Office PCs, Printers, Photocopier, and Projectors assumed to operate 5 hours/day.
- ACs assumed to operate 6 hours/day

Load Calculation

- LED Lights

$$Daily\ Load: 3495 \times 8 = 27960\ Wh$$

$$Monthly\ Load: 27960 \times 22 = 615820\ Wh$$

- Tube Lights:

$$Daily\ Load: 2590 \times 8 = 20720\ Wh$$

$$Monthly\ Load: 20720 \times 22 = 455840\ Wh$$

- Ceiling Fans:

$$Daily\ Load: 11250 \times 8 = 90000\ Wh$$

$$Monthly\ Load: 90000 \times 22 = 1980000\ \text{Wh}$$

- Wall Bracket Fans:

$$Daily\ Load: 330 \times 8 = 2640\ Wh$$

$$Monthly\ Load: 2{,}640 \times 22 = 58{,}080\ Wh$$

- Projectors:

$$Daily\ Load: 200 \times 5 = 1{,}000\ Wh$$

$$Monthly\ Load: 1{,}000 \times 22 = 22{,}000\ Wh$$

- CCTV Cameras

$$Daily\ Load: 60 \times 8 = 480\ Wh$$

$$Monthly\ Load: 480 \times 22 = 10{,}560\ Wh$$

- Water Coolers

$$Daily\ Load: 1{,}200 \times 8 = 9{,}600\ Wh$$

$$Monthly\ Load: 9{,}600 \times 22 = 211{,}200\ Wh$$

- Office PCs:

$$Daily\ Load: 4200 \times 5 = 21000\ Wh$$

$$Monthly\ Load: 21000 \times 22 = 462{,}000\ Wh$$

- Office Photocopier:

$$Daily\ Load: 1600 \times 5 = 8{,}000\ Wh$$

$$Monthly\ Load: 8{,}000 \times 22 = 176{,}000\ Wh$$

- Office Printers:

$$Daily\ Load: 750 \times 5 = 3{,}750\ Wh$$

$$Monthly\ Load: 3{,}750 \times 22 = 82{,}500\ Wh$$

- ACs (1 ton each):

$$Daily\ Load: 19200 \times 6 = 115200\ Wh$$

$$Monthly\ Load: 115200 \times 22 = 2534400\ Wh$$

Total Monthly Load Calculation

$Total\ Monthly\ Load\ (Wh)$

$$= 615820 + 455840 + 1980000 + 58{,}080 + 22{,}000 + 10{,}560 + 211200 + 462{,}000 + 176000 + 82{,}500 + 2534400$$

$$\boldsymbol{Total\ Monthly\ Load\ (Wh)} = \frac{6608400}{\mathbf{1000}}\boldsymbol{Wh}$$

$$\boldsymbol{Total\ Monthly\ Load\ (kWh)} = 6{,}608.4\ \boldsymbol{kWh}$$

Applying Diversity Factor: Assume a diversity factor of 0.8 (not all equipment is used at the same time).

$$Adjusted\ Monthly\ Load\ (kWh) = 6608.4 \times 0.8 = 5286.72\ kWh$$

Power Factor: Assume a power factor of 0.9 for the entire block.

$$Effective\ Load\ (kWh) = 5286.72 \times 0.9 = 4{,}758.0458\ kWh$$

The effective monthly load for the university block, considering diversity and power factor, is approximately **4758.0458 kWh**.

7.2. Load curve

Interval	LED Lights	Tube Lights	Ceiling Fans	Wall Bracket Fans	Projectors	Office PCs	ACs	Other Equipment	Total Load (W)
8:30 - 9:00	3495	2590	11250	330	50	2100	10000	2,710	32525
9:00 - 9:30	3495	2590	11250	330	50	2100	10000	2,710	32525
9:30 - 10:00	3495	2590	11250	330	100	2100	10000	2,710	32525
10:00 - 10:30	3495	2590	11250	330	200	2100	10000	2,710	32525
10:30 - 11:00	3495	2590	11250	330	200	4200	10000	2,710	34625
11:00 - 11:30	3495	2590	11250	330	200	4200	15000	2,710	39625
11:30 - 12:00	3495	2590	11250	330	200	4200	15000	2,710	39625
12:00 - 12:30	3495	2590	11250	330	200	4200	15000	2,710	39625
12:30 - 1:00	3495	2590	11250	330	200	4200	15000	2,710	39625

1:00 - 1:30	3495	11250	2,850	330	200	4200	15000	2,710	39625
1:30 - 2:00	3495	11250	2,850	330	200	4200	15000	2,710	39625
2:00 - 2:30	3495	11250	2,850	330	200	4200	10000	2,710	34625
2:30 - 3:00	3495	11250	2,850	330	200	4200	10000	2,710	34625
3:00 - 3:30	3495	11250	2,850	330	200	2100	10000	2,710	32525
3:30 - 4:00	3495	11250	2,850	330	200	2100	10000	2,710	32525
4:00 - 4:30	3495	11250	2,850	330	200	2100	8000	2,710	32525

Load variation with time

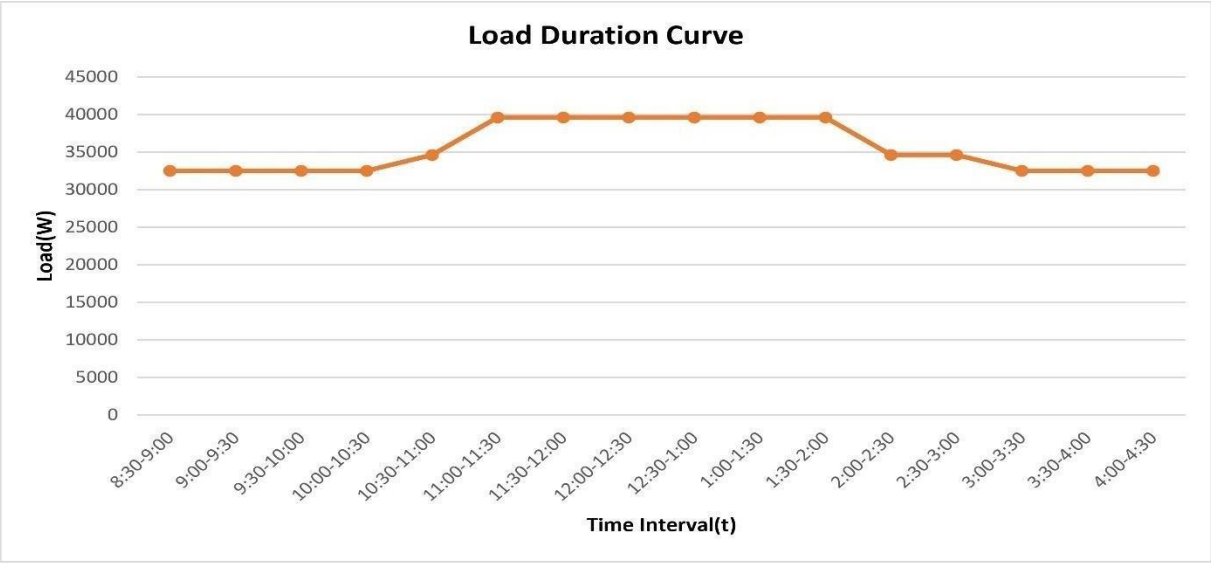

Figure 1 Load variation curve

7.3. Monthly tariff

Based on the electricity tariff information provided by the AJK Electricity Department for Mirpur, Azad Kashmir, the applicable tariff for educational institutions falls under the "General Services" category.

General Services Tariff

- Fixed Charges: Rs. 29.81 per kW per month
- Variable Charges: Rs. 31.93 per kWh

We previously calculated the total monthly load for the university block to be approximately 3,998.17 kWh.

Fixed Charges Calculation:

$$Fixed\ Charges = 100\ kW \times Rs.29.81 = Rs.2981\ per\ month$$

Variable Charges Calculation:

$$Variable\ Charges = 4{,}758.0458\ kWh * Rs.31.93 = Rs.151781.661\ per\ month$$

Total Monthly Electricity Cost:

$$Total\ Cost = Fixed\ Charges + Variable\ Charges$$

$$\boldsymbol{Total\ Cost = Rs.2{,}981 + Rs.}1{,}51{,}781.661 \boldsymbol{= Rs.}154762.661\ \boldsymbol{per\ month}$$

8. Generator Size

Calculate the Total Connected Load in kW:

- The total connected load is the sum of the wattages of all equipment.
- Based on the above calculation, the total daily load is 309.208 kWh/day

Convert kWh to kW:

- Since the daily load is given in kWh and used over 8 hours, the connected load in kW would be the daily kWh divided by the number of hours used.

Total Connected Load$=\frac{309.208KWh}{8\ hours}=38.651kw$

Apply a Safety Factor:

- To ensure reliability, it's common to apply a safety factor of 1.2 to 1.5.
- Using a safety factor of 1.25:

Adjusted Load$=38.651\ \text{kW}\times 1.25=48.31\ \text{kW}$

Convert kW to kVA:

- Generators are typically rated in kVA, not kW.
- To convert kW to kVA, divide by the power factor (typically 0.8 for general usage).

Generator Size$=\frac{48.31\ kW}{0.8}=60.393\ \text{kVA}$

9. Conclusion

To ensure uninterrupted power supply to the Mechanical Engineering Department, a 60 kVA generator is recommended. This capacity will handle the peak load efficiently, provide a safety margin for load variations and accommodate potential future increases in power demand. This generator size ensures that the department's energy needs are met without overloading the system, thus maintaining operational reliability and efficiency.

The End