**COMPLEX ENGINEERING PROBLEM REPORT**



**"Electrical Load Calculation for Mechanical Engineering Department"**

Submitted to

**Engr. Kamran Afzal**

Department of Mechanical Engineering

in partial fulfillment of the requirements for the

**Course: Power Plants**

|  |  |  |
| --- | --- | --- |
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**Table of Contents**

[**COMPLEX ENGINEERING PROBLEM STATEMENT** 3](#_Toc175327456)

[**SITE SELECTION** 4](#_Toc175327457)

[**Connected Load Calculation** 4](#_Toc175327458)

[**LOAD PROFILE PER HOUR** 9](#_Toc175327459)

[**DAILY LOAD PROFILE** 11](#_Toc175327460)

[**Optimum Sizing of Generator** 12](#_Toc175327461)

[**Conclusion** 16](#_Toc175327462)

# **COMPLEX ENGINEERING PROBLEM STATEMENT**

The primary objective of this Continuous Evaluation Project (CEP) is to calculate the electric load for the Mechanical Engineering Department. This objective leads to the economic and environmental evaluation of an optimum sized power plant for building of Mechanical Engineering Department MUST.

# **SITE SELECTION**

The building selected for this complex engineering problem is Mechanical Department MUST. We will require comprehensive information regarding the different electrical components and how they are used within the structure in order to calculate the building's electric load.

# **Connected Load Calculation**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **All Floors Combined Connected Load** | | | |  | |
|  |  | **Mechanics of Material Lab** | | | |  | |
| **Sr.**  **No** | **Quantity** | **Appliances** | **Load (W)** | | **Power (W)** | **Power (KW)** | |
| **1** | 6 | Fans | 70 | | 210 | 0.21 | |
| **2** | 18 | Tube lights | 40 | | 720 | 0.72 | |
| **3** | 1 | PC | 200 | | 200 | 0.2 | |
| **4** | 1 | Printer | 550 | | 550 | 0.55 | |
| **5** | 2 | AC | 3500 | | 7000 | 7 | |
|  |  | **Room 6** | | | |  | |
| **1** | 7 | LED bulbs | 12 | | 84 | 0.084 | |
| **2** | 6 | Fans | 70 | | 420 | 0.42 | |
| **3** | 1 | Camera | 30 | | 30 | 0.03 | |
| **4** | 1 | Projector | 350 | | 350 | 0.350 | |
|  |  | **Room7** | | | |  | |
| **1** | 3 | Fans | 70 | | 210 | 0.21 | |
| **2** | 7 | LED bulbs | 12 | | 84 | 0.084 | |
| **3** | 1 | Camera | 30 | | 30 | 0.03 | |
| **Teachers Toilet** | | | | | | | |
| **1** | 4 | Fans | 70 | 280 | | | 0.28 |
| **2** | 4 | Tube lights | 40 | 160 | | | 0.16 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Drawing Hall** | | | |  | |
| **Sr.**  **No** | **Quantity** | **Appliances** | **Load (W)** | | **Power (W)** | **Power (KW)** | |
| **1** | 10 | Fans | 70 | | 700 | 0.7 | |
| **2** | 20 | Tube lights | 40 | | 800 | 0.8 | |
| **3** | 36 | LED Bulbs | 12 | | 432 | 0.432 | |
| **4** | 1 | Camera | 30 | | 30 | 0.03 | |
|  |  | **Library** | | | |  | |
| **1** | 7 | LED bulbs | 12 | | 84 | 0.084 | |
| **2** | 6 | Fans | 70 | | 420 | 0.42 | |
| **3** | 1 | AC | 3500 | | 3500 | 3.5 | |
| **4** | 1 | Dispenser | 350 | | 350 | 0.350 | |
| **5** | 1 | Printer | 550 | | 550 | 0.55 | |
| **6** | 1 | PC | 200 | | 200 | 0.2 | |
|  |  | **Control Lab** | | | |  | |
| **1** | 3 | Fans | 70 | | 210 | 0.21 | |
| **2** | 7 | LED bulbs | 12 | | 84 | 0.084 | |
| **3** | 1 | Camera | 30 | | 30 | 0.03 | |
| **4** | 1 | AC | 3500 | | 3500 | 0.35 | |
| **5** | 1 | PC | 200 | | 200 | 0.2 | |
| **Examination Hall** | | | | | | | |
| **1** | 10 | Fans | 70 | 700 | | | 0.7 |
| **2** | 20 | Tube lights | 40 | 800 | | | 0.8 |
| **3** | 36 | LED Bulb | 12 | 432 | | | 0.432 |
| **4** | 1 | Camera | 30 | 30 | | | 0.03 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Room 1** | | |  |
| **1** | 3 | Fans | 70 | 210 | 0.21 |
| **2** | 14 | Tube lights | 40 | 560 | 0.56 |
| **3** | 18 | LED Bulbs | 12 | 96 | 0.096 |
| **4** | 1 | Camera | 30 | 30 | 0.03 |
| **5** | 1 | Projector | 350 | 350 | 0.35 |
|  |  | **Student Washrooms** | | |  |
| **1** | 16 | bulb | 12 | 192 | 0.192 |
| **2** | 20 | Fans | 70 | 1400 | 1.4 |
| **3** | 1 | Geyser | 2000 | 2000 | 2 |
|  |  | **CAD Lab** | | |  |
| **1** | 6 | Fans | 70 | 420 | 0.42 |
| **2** | 18 | Tube light | 40 | 720 | 0.72 |
| **3** | 2 | AC | 3500 | 7000 | 0.7 |
| **4** | 32 | PCs | 200 | 6400 | 6.4 |
| **5** | 1 | Dispenser | 200 | 200 | 0.2 |
| **6** | 2 | Camera | 30 | 60 | 0.06 |
| **7** | 1 | Projector | 350 | 350 | 0.35 |
| **8** | 1 | Printer | 550 | 1100 | 1.1 |
| **HVAC Lab** | | | | | |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **1** | 18 | Tube Lights | 40 | | 720 | 0.72 | |
| **2** | 6 | Fans | 70 | | 420 | 0.42 | |
| **3** | 1 | AC | 3500 | | 3500 | 3.5 | |
| **4** | 1 | Water Cooler | 800 | | 800 | 0.8 | |
| **5** | 1 | Printer | 550 | | 550 | 0.55 | |
| **Total Office** | | | | | | | |
| **1** | 92 | Tube Lights | 40 | 3680 | | 3.68 | |
| **2** | 31 | Fans | 70 | 2170 | | 2.17 | |
| **3** | 4 | AC | 3500 | 14000 | | 14 | |
| **4** | 9 | Printer | 550 | 4950 | | 4.95 | |
| **5** | 2 | Dispenser | 200 | 400 | | 0.4 | |
| **Fluid Lab** | | | | | | | |
| **1** | 18 | Tube Lights | 40 | 720 | | | 0.72 |
| **2** | 6 | Fans | 70 | 420 | | | 0.42 |
| **3** | 2 | Camera | 30 | 60 | | | 0.06 |
| **4** | 1 | Water Cooler | 800 | 800 | | | 0.8 |
| **5** | 1 | PC | 200 | 200 | | | 0.2 |
| **6** | 5 | Instruments | 598 | 2990 | | | 2.99 |
| **Mechanical Hall** | | | | | | | |
| **1** | 8 | Tube Lights | 40 | 320 | | | 0.32 |
| **2** | 141 | Small Bulbs | 12 | 1692 | | | 1.692 |
| **3** | 8 | Fans | 70 | 560 | | | 0.56 |
| **4** | 4 | AC | 10625 | 42500 | | | 42.5 |
| **5** | 2 | Projector | 350 | 700 | | | 0.7 |
| **6** | 6 | Speaker | 50 | 300 | | | 0.3 |
| **Room 5** | | | | | | | |
| **1** | 6 | Fans | 70 | 420 | | | 0.42 |
| **2** | 28 | Tube Lights | 40 | 1120 | | | 1.12 |
| **3** | 1 | Projector | 350 | 350 | | | 0.35 |
| **4** | 1 | Speaker | 50 | 50 | | | 0.05 |
| **Room 4** | | | | | | | |
| **1** | 3 | Fans | 70 | 210 | | | 0.21 |
| **2** | 6 | LED Bulbs | 12 | 48 | | | 0.048 |
| **Room 3** | | | | | | | |
| **1** | 3 | Fans | 70 | 210 | | | 0.21 |
| **2** | 12 | Tube Lights | 40 | 480 | | | 0.48 |
| **3** | 1 | Camera | 30 | 30 | | | 0.03 |
| **4** | 1 | Projector | 350 | 350 | | | 0.35 |
| **5** | 1 | Speaker | 50 | 50 | | | 0.05 |
| **Room 2** | | | | | | | |
| **1** | 3 | Fans | 70 | 210 | | | 0.21 |
| **2** | 12 | Tube Lights | 40 | 480 | | | 0.48 |
| **3** | 1 | Projector | 350 | 350 | | | 0.35 |
| **Ground Floor Corridor** | | | | | | | |
| **1** | 13 | Tube Lights | 40 | 520 | | | 0.52 |
| **2** | 6 | Camera | 30 | 180 | | | 0.18 |
| **3** | 13 | LED Bulbs | 12 | 156 | | | 0.156 |
| **Mechanics of Machines Lab** | | | | | | | |
| **1** | 6 | Fans | 70 | 420 | | | 0.42 |
| **2** | 16 | Tube Lights | 40 | 640 | | | 0.64 |
| **3** | 2 | AC | 3500 | 7000 | | | 7 |
| **4** | 1 | Water Cooler | 200 | 200 | | | 0.2 |
| **5** | 1 | PC | 200 | 200 | | | 0.2 |
| **6** | 1 | Printer | 550 | 550 | | | 0.55 |
| **HMT Lab** | | | | | | | |
| **1** | 6 | Fans | 70 | 420 | | | 0.42 |
| **2** | 16 | Tube Lights | 40 | 640 | | | 0.64 |
| **3** | 1 | Printer | 550 | 550 | | | 0.55 |
| **4** | 1 | Water Cooler | 200 | 200 | | | 0.2 |
| **5** | 1 | AC | 5260 | 5260 | | | 5.26 |
| **Workshop** | | | | | | | |
| **1** | 20 | Fans | 70 | 1400 | | | 1.4 |
| **2** | 2 | Wall Fans | 55 | 110 | | | 0.11 |
| **3** | 1 | Dispenser | 200 | 200 | | | 0.2 |
| **4** | 1 | Air Cooler | 150 | 150 | | | 0.15 |
| **5** | 1 | PC | 120 | 120 | | | 0.12 |
| **6** | 30 | Tube Lights | 40 | 1200 | | | 1.2 |
| **7** | 10 | Machines | 6000 | 60000 | | | 60 |
| **Thermodynamics Lab** | | | | | | | |
| **1** | 9 | Fans | 70 | 630 | | | 0.63 |
| **2** | 48 | Bulbs | 12 | 576 | | | 0.576 |
| **3** | 1 | Dispenser | 200 | 200 | | | 0.2 |
| **4** | 2 | PC | 200 | 400 | | | 0.4 |
| **5** | 1 | Wall Fans | 45 | 45 | | | 0.045 |
| **6** | 1 | AC | 3500 | 3500 | | | 3.5 |
| **7** | 6 | Apparatus | 786.6 | 4719.6 | | | 4.7196 |
| **Previous Civil Library** | | | | | | | |
| **1** | 4 | Tube Lights | 40 | 160 | | | 0.16 |
| **2** | 3 | Fans | 70 | 210 | | | 0.21 |
| **3** | 1 | AC | 3500 | 3500 | | | 3.5 |
| **Previous Survey Store** | | | | | | | |
| **1** | 7 | Tube Lights | 40 | 280 | | | 0.28 |
| **2** | 5 | Fans | 70 | 350 | | | 0.35 |
| **3** | 1 | PC | 200 | 200 | | | 0.2 |
| **4** | 1 | AC | 3500 | 3500 | | | 3.5 |
|  |  |  |  | Total Watt=229664.6W | | | Total KW=229.6646 |

# **LOAD PROFILE PER HOUR**

|  |  |  |
| --- | --- | --- |
| **Time (hours)** | **Meter Reading** | **KW** |
| 1:00 AM | 207205.30 | 1.52 |
| 2:00 AM | 207209.45 | 1.52 |
| 3:00 AM | 207215.12 | 1.52 |
| 4:00 AM | 207230.10 | 1.52 |
| 5:00 AM | 207235.41 | 1.52 |
| 6:00 AM | 207237.81 | 1.52 |
| 7:00 AM | 207241.11 | 1.52 |
| 8:00 AM | 207245.45 | 1.8423 |
| 9:00 AM | 207248.87 | 3.77 |
| 10:00 AM | 207254.13 | 5.01 |
| 11:00 AM | 207260.11 | 4.1 |
| 12:00 AM | 207263.76 | 3.89 |
| 1:PM | 207265.31 | 3.3 |
| 2:PM | 207268.44 | 2.37 |
| 3:PM | 207273.50 | 3.45 |
| 4:PM | 207275.19 | 2.36 |
| 5:PM | 207277.30 | 2.07 |
| 6:PM | 207279.01 | 1.52 |
| 7:PM | 207283.71 | 1.52 |
| 8:PM | 207286.83 | 1.52 |
| 9:PM | 207289.30 | 1.52 |
| 10:PM | 207291.84 | 1.52 |
| 11:PM | 207295.33 | 1.52 |
| 12:AM | 207299.80 | 1.52 |
| **Average** | 189987.6296 | 2.065 |

Peak Load= 5.01kW W

# **DAILY LOAD PROFILE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr No** | **Date** | **Time (Daily)** | **Load (kW)** | **Used Units(kW)** |
| **1** | 05-Aug | 9:30 AM | 207250.91 | 0 |
| **2** | 06-Aug | 9:30 AM | 207301.31 | 50.4 |
| **3** | 07-Aug | 9:30 AM | 207348.03 | 46.72 |
| **4** | 08-Aug | 9:30 AM | 207388.71 | 40.68 |
| **5** | 09-Aug | 9:30 AM | 207441.44 | 52.73 |
| **6** | 10-Aug | 9:30 AM | 207501.87 | 60.43 |
| **7** | 11-Aug | 9:30 AM | 207550.69 | 48.82 |
| **8** | 12-Aug | 9:30 AM | 207611.89 | 61.2 |

# **Optimum Sizing of Generator**

We use the following condition for the selection of the generator.

IF demand <0.5 engine= output 0

If demand is > engine output = output engine

IF load demand is < engine output but > 50% of any output

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hours | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Load (kW) | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.8423 | 3.77 | 5.01 | 4.1 | 3.89 |
| KVA | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Grid Req | 8.48 | 8.48 | 8.48 | 8.48 | 8.48 | 8.48 | 8.48 | 8.1577 | 6.23 | 4.99 | 5.9 | 6.11 |
| Gas Price | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 |
| DRH | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**For 10KVA**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hours | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Load (kW) | 3.3 | 2.37 | 3.45 | 2.36 | 2.07 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 |
| KVA | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Grid Req | 6.7 | 7.63 | 6.55 | 7.64 | 7.93 | 8.48 | 8.48 | 8.48 | 8.48 | 8.48 | 8.48 | 8.48 |
| Gas Price | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 |
| DRH | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**For 20 KVA**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hours | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Load (kW) | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.8423 | 3.77 | 5.01 | 4.1 | 3.89 |
| KVA | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Grid Req | 18.48 | 18.48 | 18.48 | 18.48 | 18.48 | 18.48 | 18.48 | 18.1577 | 16.23 | 14.99 | 15.9 | 16.11 |
| Gas Price | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 |
| DRH | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hours | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Load (kW) | 3.3 | 2.37 | 3.45 | 2.36 | 2.07 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 |
| KVA | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Grid Req | 16.7 | 17.63 | 16.55 | 17.64 | 17.93 | 18.48 | 18.48 | 18.48 | 18.48 | 18.48 | 18.48 | 18.48 |
| Gas Price | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 |
| DRH | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

**For 30 KVA**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hours | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Load (kW) | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.8423 | 3.77 | 5.01 | 4.1 | 3.89 |
| KVA | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Grid Req | 28.48 | 28.48 | 28.48 | 28.48 | 28.48 | 28.48 | 28.48 | 28.1577 | 26.23 | 24.99 | 25.9 | 26.11 |
| Gas Price | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 |
| DRH | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hours | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Load (kW) | 3.3 | 2.37 | 3.45 | 2.36 | 2.07 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 | 1.52 |
| KVA | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Grid Req | 26.7 | 27.63 | 26.55 | 27.64 | 27.93 | 28.48 | 28.48 | 28.48 | 28.48 | 28.48 | 28.48 | 28.48 |
| Gas Price | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 | 244 |
| DRH | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Total cost= generator cost + generator installation cost + (Fuel hours \*running hours \* fuel consumption per hour)

Payback Period = total cost / saving cost

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Power Plant Size (kVA)** | **Total Cost** | **Net saving** | **Running Hours** | **Payback Hours** |
| 10 | 345054.54 | 38098 | 3 | 9.06 |
| 20 | 800024.24 | 69770 | 2 | 11.47 |
| 30 | 1300010.98 | 28800 | 1 | 45.14 |

# **Conclusion**

After evaluating three generator options—10kVA, 20kVA, and 30kVA—for the Mechanical Engineering Department, the 20kVA generator was selected as the most suitable choice. The selection was based on a comprehensive analysis that considered total costs, potential savings, and the payback period, ensuring that the chosen generator would provide both economic and operational benefits.

The 20kVA generator has a total cost of Rs 800,024.24, which includes the purchase price, installation, and associated costs. When operating for 2 hours daily, it generates a net annual saving of Rs 69,770. This results in a payback period of approximately 11.47 years, making it the most cost-effective option among the generators considered. The payback period is a critical factor in assessing the viability of the investment, as it reflects the time required to recover the initial expenditure through savings generated by the generator.

In comparison, the 10kVA and 30kVA generators, while offering lower upfront costs, provide significantly lower net annual savings of Rs 38,098 and Rs 28,800, respectively. These reduced savings contribute to longer payback periods, diminishing their overall economic attractiveness. The 10kVA generator, while smaller and less expensive, does not offer sufficient savings to justify its selection. On the other hand, the 30kVA generator, though larger, incurs higher operational costs, leading to diminished savings and a less favorable payback period.

Therefore, the 20kVA generator strikes an optimal balance between cost, efficiency, and savings, making it the most logical and economically viable choice for powering the department. This decision ensures that the department's energy needs are met in a cost-effective manner while also providing a reasonable return on investment over time.