# Demand Side Management for a Campus Infrastructure

**BATCH : A6**

**TYPE : IN-HOUSE**

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**TEAM MEMBERS**

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# Project Objectives

- To reduce the peak electricity demand by:
  - Improving the load curve
  - Proper Utilization of Diesel Generators
  - Effective utilization of existing Photovoltaic Panels

# Abstract


- Due to large industrial and overall development of the country, demand for electricity has seen to be exponentially increased during last decade.
- Demand side management (DSM) is one of the important functions in a grid that allows consumers to make informed decisions regarding their energy consumption, and helps the energy providers reduce the peak load demand and reshape the load profile.
- A load shifting demand side management technique is utilized here to transfer low priority consumer loads from high demand to off peak periods, which can intern reduce critical peak demand.
- Simulations are carried out for a university infrastructure, utilizing the existing photo-voltaic array DG generators.
- These existing assets are treated as a local grid and evaluated for four different operational scenarios. The results show significant cost savings are achievable with the proposed optimization strategy

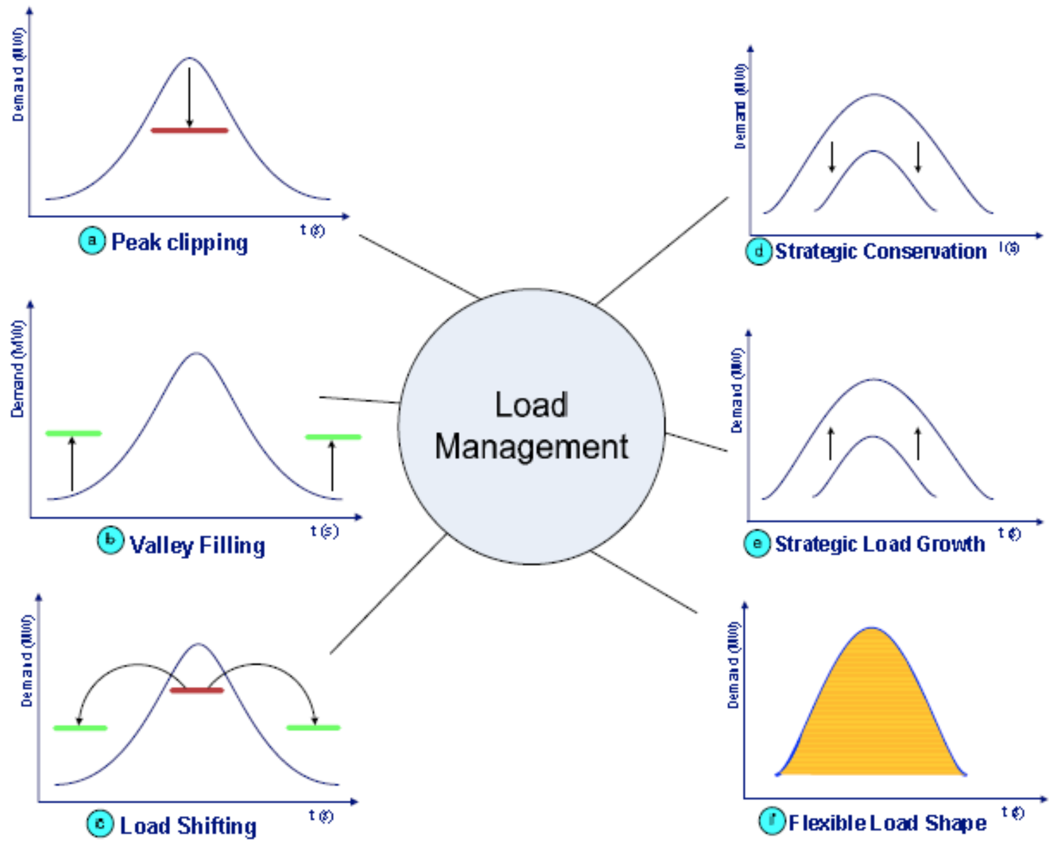
# Overview

- Simulations have been carried out for a campus infrastructure utilizing existing assets such as DG Sets & PV Panels.
  - SCENARIO 1 – Primary Supply alone
  - SCENARIO 2 – DSM during peak demand hours
  - SCENARIO 3 – Primary Supply with PV Integration
  - SCENARIO 4 – DSM with PV during Peak demand hour
  - SCENARIO 5 – Diesel Generator with PV Integration

# Literature Survey

| Author | Paper Title | Year | Summary |
| --- | --- | --- | --- |
| Nandkishor Kinhekar | Utility Oriented Demand Side Management Using Smart AC and Micro DC Grid Cooperative | 2015 | Demonstrated a load shifting demand side management (DSM) technique used to shift AC industrial loads in response to time of day (TOD) tariff |
| Logenthiran.T | Demand Side Management in Smart Grid Using Heuristic Optimization | 2012 | Proposed a day-ahead load shifting technique, mathematically formulated as a minimization problem |
| Govardhan.M | Impact of demand side management on unit commitment problem | 2014 | Uses two essential approaches of energy balance (i.e. energy shifting) and load reduction during peak hours. |

# DSM Strategies

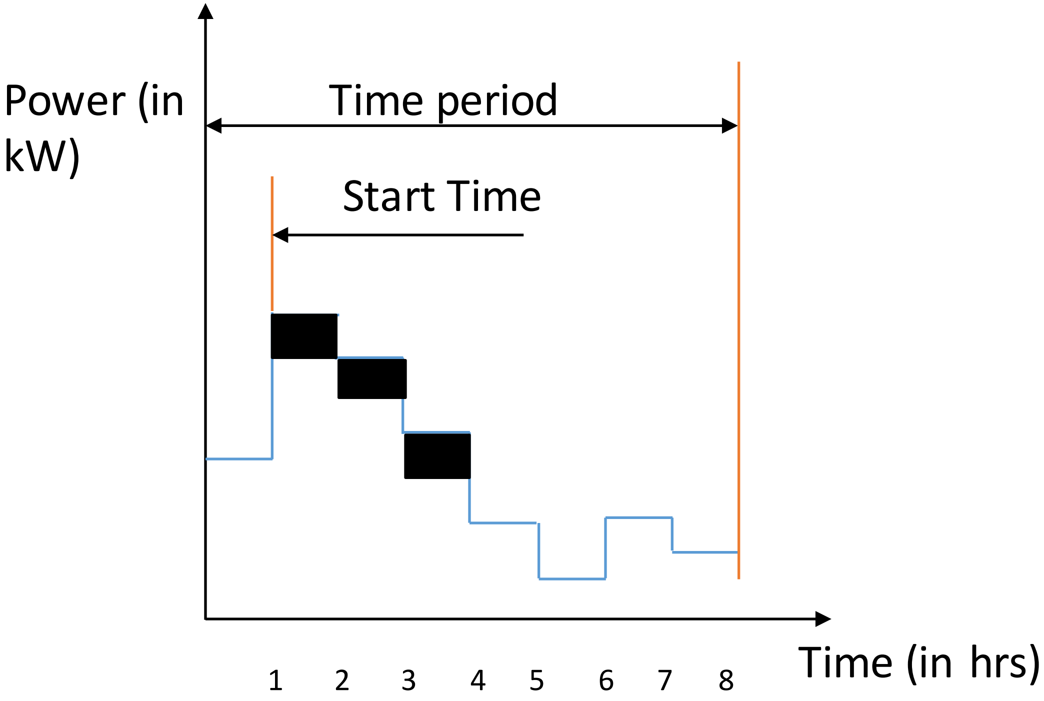


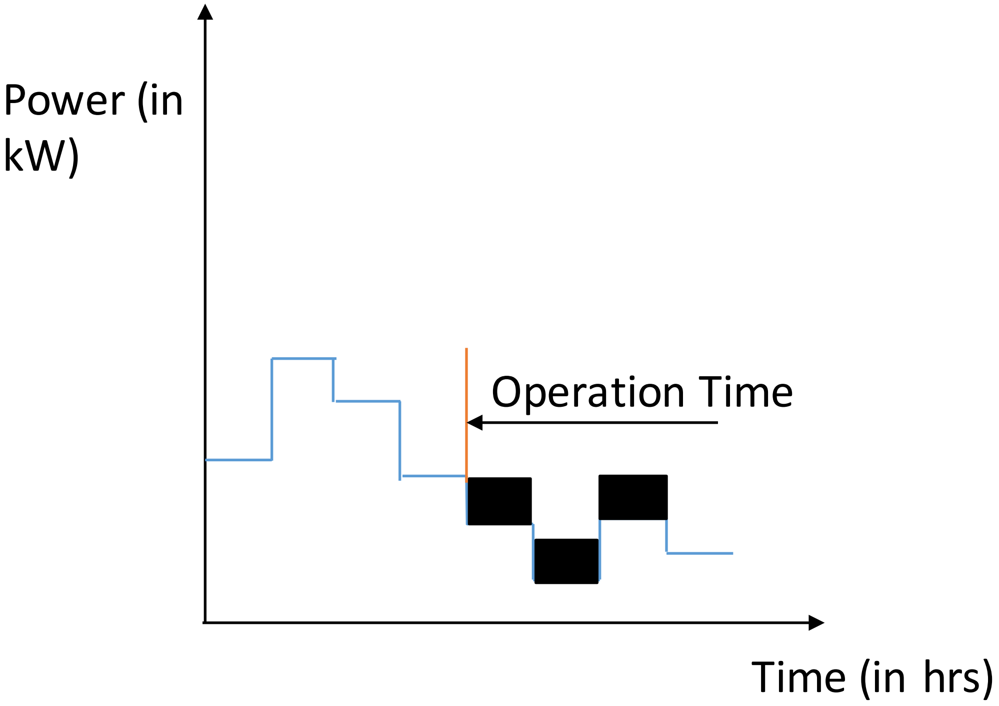

## Load Shifting

- Most widely applied load management technique in current distribution networks.
- Shifting of loads from peak periods to off peak periods
- Alternative to traditional load shedding

# DSM Modelling

## Load Shifting Process



# Device Parameters

| |
|---|
| Device Name |
| Device Number |
| Device Rating |
| Initial Scheduling Time |
| Operation Time |
| Operation period |
| Maximum permissible delay |
| Original Delay |

- Each and every device data stored in separate memory connected to microprocessor.
- These data can be retrieved at any time and it implies the device details like device type, starting time, operation time, etc.,
- This data tells about the information, when to switch on/off the particular device during real time load shifting

# CONSTRAINTS INVOLVED

CONSTRAINTS

- **SHIFTABLE DEVICE:** Maximum number of shiftable devices at time(t) should not exceed 9 device types
- **MAXIMUM PERMISSIBLE DELAY:** Maximum allowable delay selection should not exceed 12 time steps
- **LOCAL ENERGY GENERATORS:** generate electric energy that is utilized locally

# DSM Modelling

Proposed load shifting technique is mathematically formulated as follows.

$$Minimize \sum_{t=1}^{N} (ACP_{ac}(t) - Objective(t))^2$$

Where Objective(t) is the value of the objective curve at time t
$ACP_{ac}(t)$ is the actual consumption at time t.

$$Objective(t) = \frac{C_m}{C_{max}} \times \frac{1}{C(t)} \times \sum_{s=1}^{N=48} P_{fixa}(s)$$

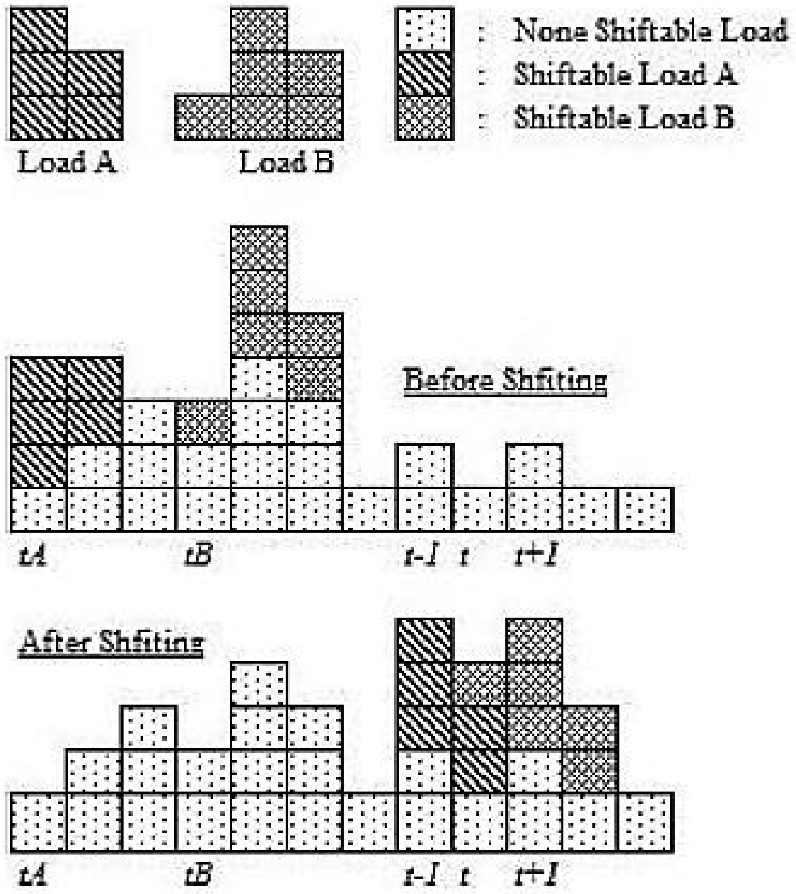
# Shifting of Loads

$$Connect(t) = \sum_{i=1}^{N} \sum_{k=1}^{D} Y_{kit} \times P_{1k} + \sum_{l=1}^{j-1} \sum_{i=1}^{t-1} \sum_{k=1}^{D} Y_{ki(t-1)} \times P_{(1+l)k} \times \Delta t$$

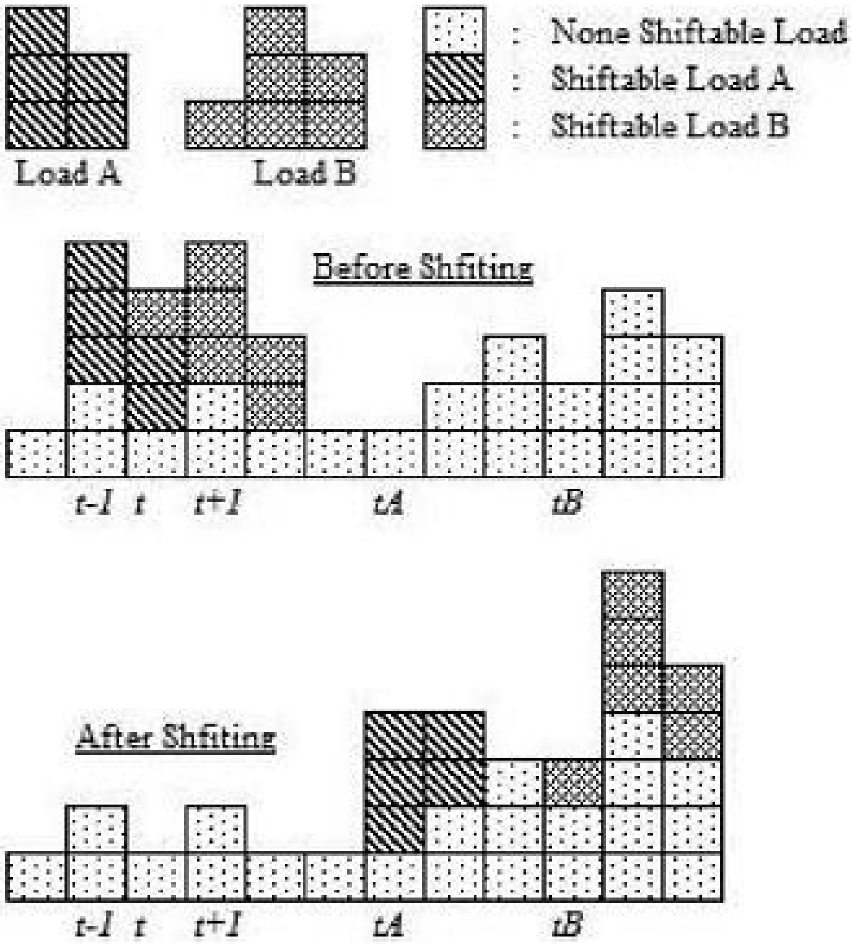
Where $Y_{kit}$ is the number of devices of type that are shifted from time step i to t,D is the number of device types, $P_{1k}$ and $P_{(1+l)k}$ are the power consumptions at time steps 1 and (1+l).

$$Disconnect(t) = \sum_{q=t+1}^{t+m} \sum_{k=1}^{D} Y_{\underset{t}{kq}} \times P_{1k} + \sum_{l=1}^{j-1} \sum_{q=t+1}^{t+m} \sum_{k=1}^{D} Y_{kq(t-1)} \times P_{(1+l)k} \times \Delta t$$

Where $Y_{ktq}$ is the number of devices of type that are delayed from time step t to q , m is the maximum allowable delay.




Connect




Disconnect

- The total number of controllable devices at a particular time step must be less than or equal to the total number of available devices at that time step. A constraint related to this can be formulated as: -

$$\sum_{t=1}^{N} Y_{kit} \leq Ctrlable(i)$$

- The power balancing equation for entire distribution system is given as :-

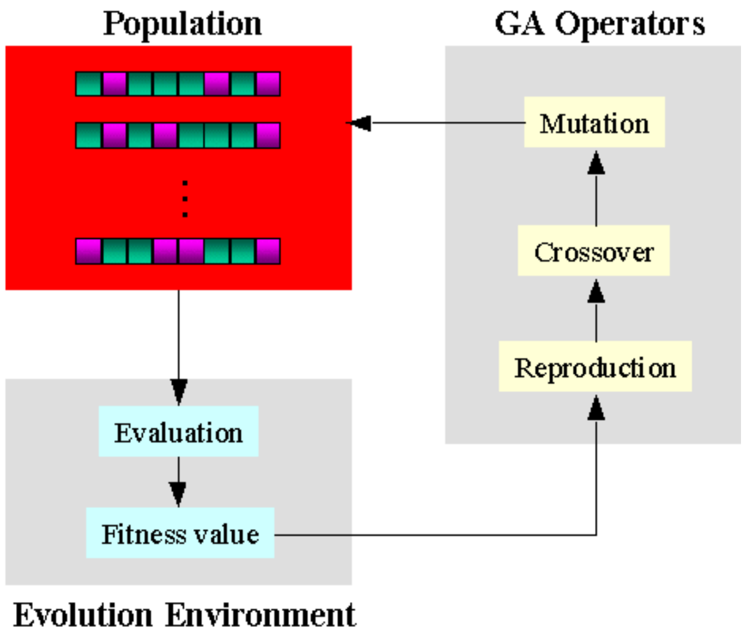
$$P_{L,dc}(t) + P_{L,ac}(t) + \sum_{i=1}^{btnum} P^{c}_{bt,i,t} + P_{\left(\frac{ac}{dc}\right)Loss}(t)$$

$$= \sum_{i=1}^{btnum} P^{d}_{bt,i,t} - P_{\left(\frac{dc}{ac}\right)Loss}(t) \quad + P_{G,ac}(t)$$

# Optimization through GA

In the genetic algorithm process is as follows:

- Step 1. Determine the number of chromosomes, generation, and mutation rate and crossover rate value
- Step 2. Generate chromosome-chromosome number of the population, and the initialization value of the genes chromosome-chromosome with a random value
- Step 3. Process steps 4-7 until the number of generations is met
- Step 4. Evaluation of fitness value of chromosomes by calculating objective function
- Step 5. Chromosomes selection
- Step 5. Crossover
- Step 6. Mutation
- Step 7. New Chromosomes (Offspring)
- Step 8. Solution (Best Chromosomes)



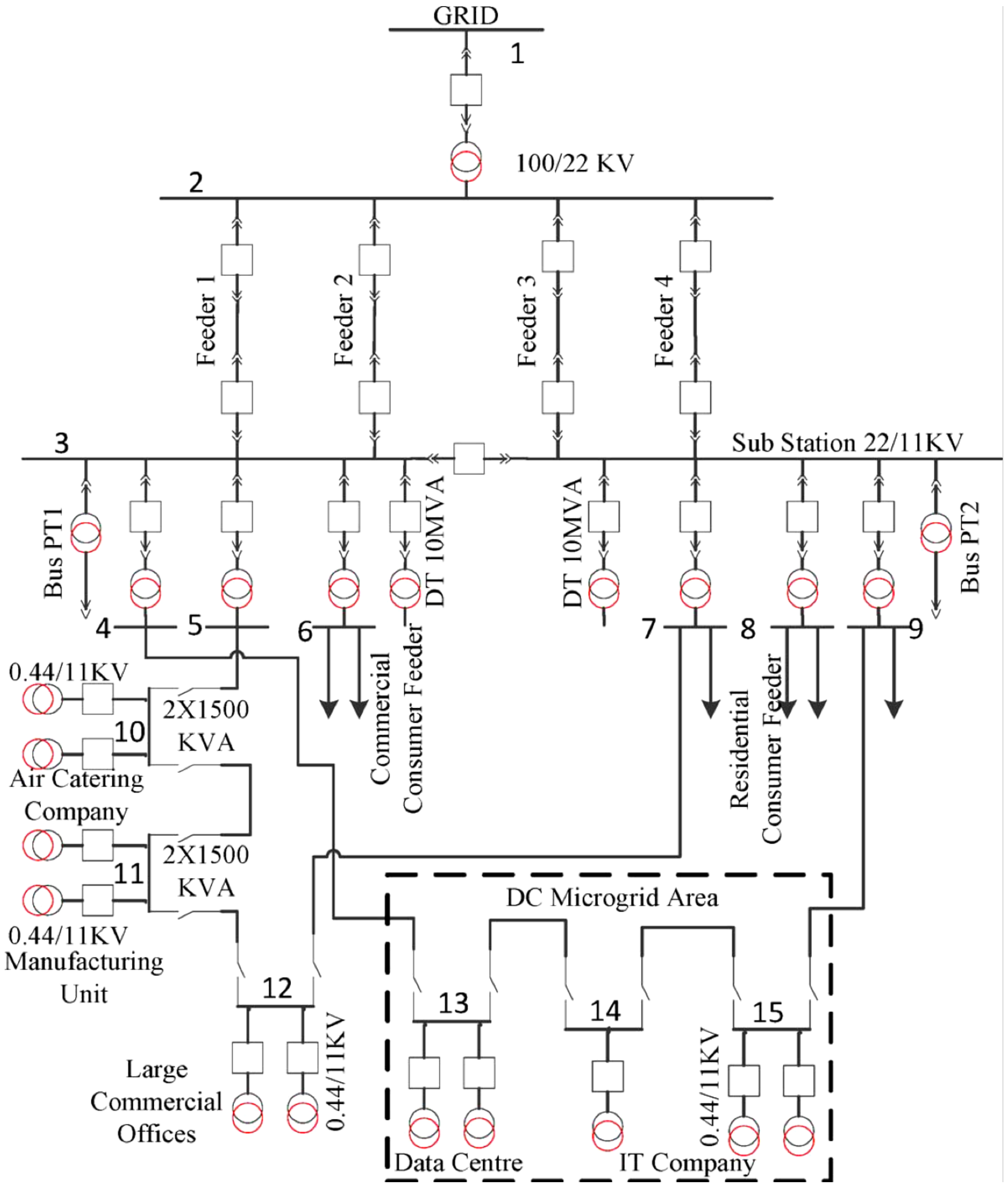
Genetic Algorithm Evolution Flow

- The optimization of the DSM model built is solved using genetic algorithm, and values shown in Table 4.1 are passed on during the program runtime to obtain the optimized solution. These values are arrived from a reference paper [21].

| **Parameters** | **Settings** |
|---|---|
| Number of chromosomes | 50 |
| Number of generations | 800 |
| Cross-over rate | 0.9 |
| Mutation rate | 0.04 |

# Test System

- The system considered for simulation is from Mumbai, the capital city of Maharashtra state in India. The approximate population and spread over area of the city is 12.5 million and 437.5 $km^2$, respectively.
- As this test system has already been studied and analysed applying DSM strategy whose results are discussed by Nandkishor Kinhekar [17], is considered here for simulation.



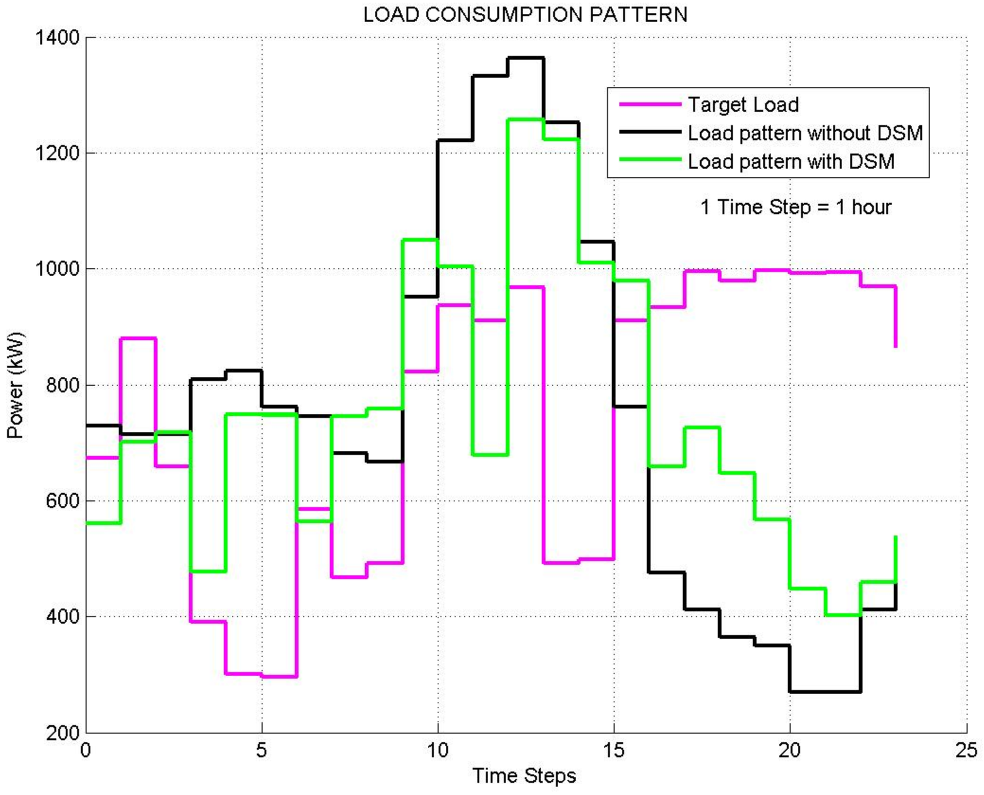
# Hourly Forecasted Load

| Time | Price | Hourly Forecasted Load (kW) | | |
|---|---|---|---|---|
| | | Residential | Commercial | Industrial |
| 08:00 – 09:00 | 12.00 | 729.4 | 923.5 | 2045.5 |
| 09:00 – 10:00 | 9.19 | 713.5 | 1154.4 | 2435.1 |
| 10:00 – 11:00 | 12.27 | 713.5 | 1443.0 | 2629.9 |
| 11:00 – 12:00 | 20.69 | 808.7 | 1558.4 | 2727.3 |
| 12:00 – 13:00 | 26.82 | 824.5 | 1673.9 | 2435.1 |
| 14:00 – 15:00 | 13.81 | 745.2 | 1673.9 | 2678.6 |
| 15:00 – 16:00 | 17.31 | 681.8 | 1587.3 | 2629.9 |
| 16:00 – 17:00 | 16.42 | 667 | 1558.4 | 2532.5 |
| 17:00 – 18:00 | 9.83 | 951.4 | 1673.9 | 2094.2 |
| 18:00 – 19:00 | 8.63 | 1220.9 | 1818.2 | 1704.5 |
| 19:00 – 20:00 | 8.87 | 1331.9 | 1500.7 | 1509.7 |

| Time | Price | Hourly Forecasted Load (kW) | | |
|---|---|---|---|---|
| | | Residential | Commercial | Industrial |
| 20:00 – 21:00 | 8.35 | 1363.6 | 1298.7 | 1363.6 |
| 22:00 – 23:00 | 16.19 | 1046.5 | 923.5 | 1120.1 |
| 23:00 – 00:00 | 8.87 | 761.1 | 577.2 | 1022.7 |
| 00:00 – 01:00 | 8.65 | 475.7 | 404.0 | 974 |
| 01:00 – 02:00 | 8.11 | 412.3 | 375.2 | 876.6 |
| 02:00 – 03:00 | 8.25 | 364.7 | 375.2 | 827.9 |
| 03:00 – 04:00 | 8.10 | 348.8 | 404.0 | 730.5 |
| 04:00 – 05:00 | 8.14 | 269.6 | 432.9 | 730.5 |
| 05:00 – 06:00 | 8.13 | 269.6 | 432.9 | 779.2 |
| 06:00 – 07:00 | 8.34 | 412.3 | 432.9 | 1120.1 |
| 07:00 – 08:00 | 9.35 | 539.1 | 663.8 | 1509.7 |

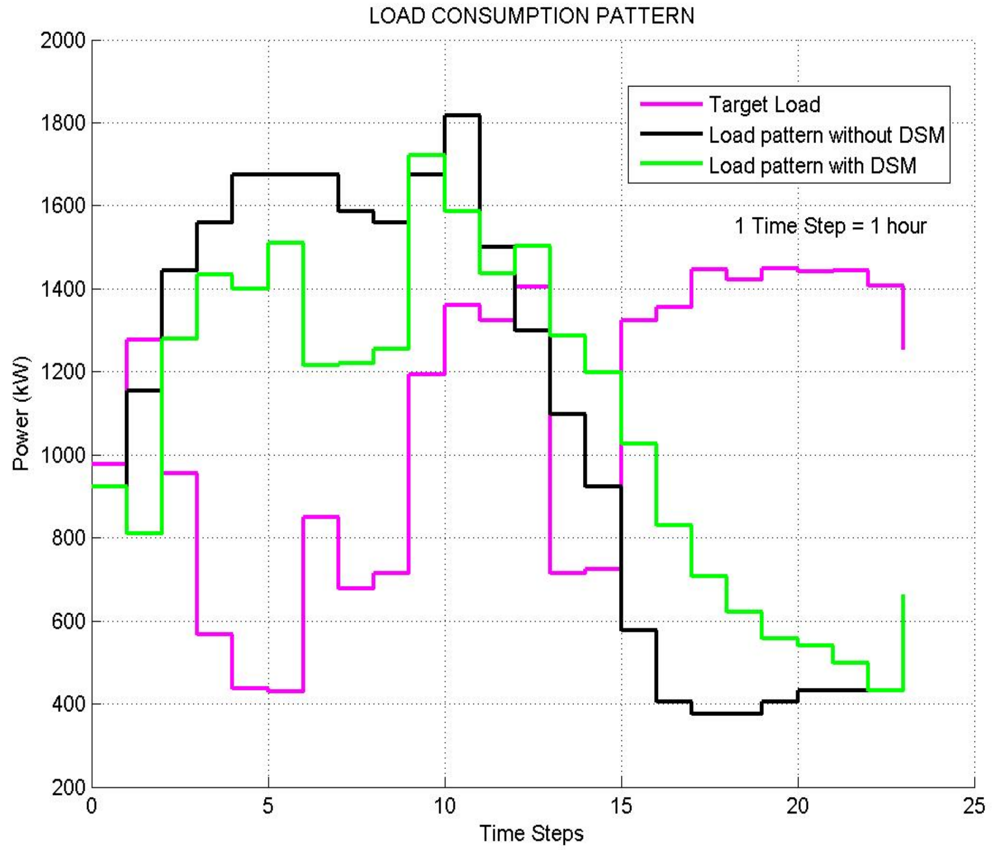
# Test System – Residential Area

| Device Type | Hourly Consumption of Device (kW) | | | Number of Devices |
|---|---|---|---|---|
| | 1st Hr | 2nd Hr | 3rd Hr | |
| Dryer | 1.2 | - | - | 189 |
| Dish Washer | 0.7 | - | - | 288 |
| Washing Machine | 0.5 | 0.4 | - | 268 |
| Oven | 1.3 | - | - | 279 |
| Iron | 1.0 | - | - | 340 |
| Vacuum Cleaner | 0.4 | - | - | 158 |
| Fan | 0.20 | 0.20 | 0.20 | 288 |
| Kettle | 2.0 | - | - | 406 |
| Toaster | 0.9 | - | - | 48 |
| Rice-Cooker | 0.85 | - | - | 59 |
| Hair Dryer | 1.5 | - | - | 58 |
| Blender | 0.3 | - | - | 66 |
| Frying Pan | 1.1 | - | - | 101 |
| Coffee Maker | 0.8 | - | - | 56 |
| Total | - | - | - | 2604 |



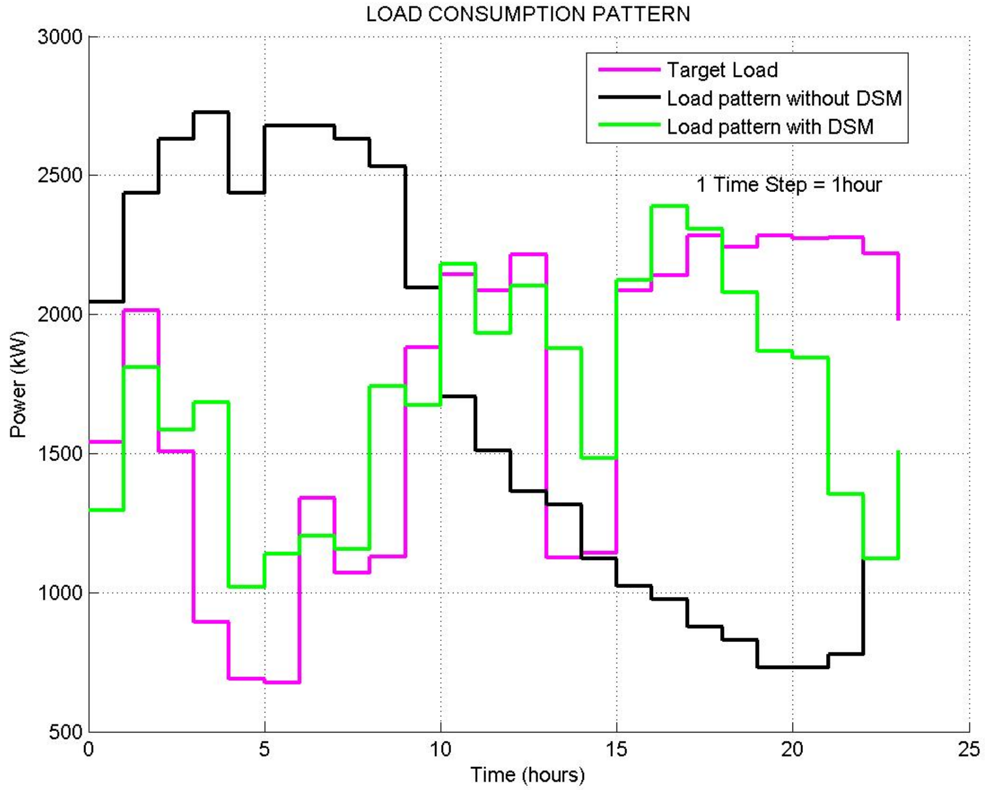
# Test System – Commercial Area

| Device Type | Hourly Consumption of Device (kW) | | | Number Devices |
|---|---|---|---|---|
| | 1st Hr | 2nd Hr | 3rd Hr | |
| Water Dispenser | 2.5 | - | - | 156 |
| Dryer | 3.5 | - | - | 117 |
| Kettle | 3.0 | 2.5 | - | 123 |
| Oven | 5.0 | - | - | 77 |
| Coffee Maker | 2.0 | 2.0 | - | 99 |
| Fan/AC | 3.5 | 3.0 | - | 93 |
| Air Conditioner | 4.0 | 3.5 | 3.0 | 56 |
| Lights | 2.0 | 1.75 | 1.5 | 87 |
| Total | - | - | - | 808 |

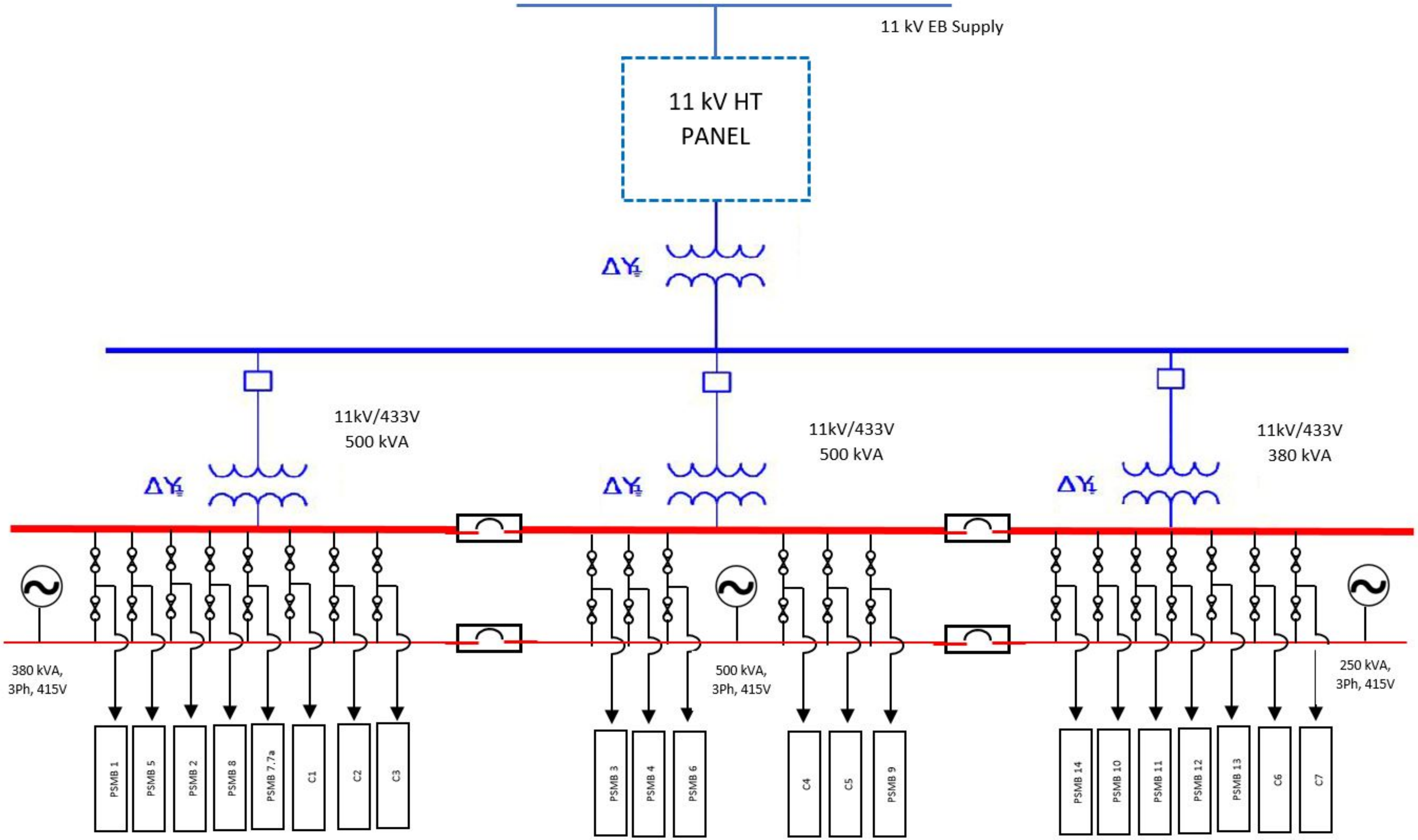


# Test System – Industrial Area

| Device Type | Hourly Consumption of Device (kW) | | | | | | Number Devices |
|---|---|---|---|---|---|---|---|
| | 1st Hr | 2nd Hr | 3rd Hr | 4th Hr | 5th Hr | 6th Hr | |
| Water Heater | 12.5 | 12.5 | 12.5 | 12.5 | - | - | 39 |
| Welding Machine | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | - | 35 |
| Fan/AC | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | - | 16 |
| Arc Furnace | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 50.0 | 8 |
| Induction Motor | 100 | 100 | 100 | 100 | 100 | 100 | 5 |
| DC Motor | 150 | 150 | 150 | - | - | - | 6 |
| Total | - | - | - | - | - | - | 109 |



# CAMPUS LOAD STUDY




Campus one line diagram

# CAMPUS LOAD STUDY

Period - ( 24 Hrs )

1. Mechanical
2. Electrical
3. Computer Science
4. Marine
5. ECE & Civil
6. Mechanical Workshop
7. Air Conditioners – Overall
8. Canteen
9. Hostel
10. Library & Admin Block
11. Lighting Loads – Classrooms

Campus Load Study - Individual Departments - 15th March 2016

| Time Stamp | PSMB 1 & 4 | | | PSMB 2 | | | PSMB 3 | | | PSMB 12 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EEE Dept | | | MEC Dept | | | CSE Dept | | | MR Dept | | |
| | R Phase | Y Phase | B Phase | R Phase | Y Phase | B Phase | R Phase | Y Phase | B Phase | R Phase | Y Phase | B Phase |
| 9:00:00 AM | 5.00 | 12.50 | 10.00 | 16.60 | 5.00 | 20.00 | 51.00 | 47.20 | 52.00 | 47.00 | 75.00 | 60.00 |
| 9:30:00 AM | 6.00 | 27.00 | 133.00 | 15.00 | 0.00 | 17.00 | 60.00 | 44.40 | 61.60 | 50.00 | 88.00 | 75.00 |
| 10:00:00 AM | 5.00 | 45.00 | 12.00 | 18.00 | 0.00 | 20.00 | 57.50 | 47.10 | 62.60 | 75.00 | 150.00 | 80.00 |
| 10:30:00 AM | 4.00 | 15.00 | 19.00 | 18.00 | 0.00 | 30.00 | 63.70 | 48.70 | 60.20 | 50.00 | 140.00 | 85.00 |
| 11:00:00 AM | 10.00 | 20.00 | 12.00 | 10.00 | 0.00 | 12.00 | 53.90 | 49.50 | 60.40 | 78.00 | 135.00 | 90.00 |
| 11:30:00 AM | 4.00 | 25.00 | 20.00 | 10.00 | 0.00 | 10.00 | 55.10 | 43.00 | 57.60 | 75.00 | 140.00 | 100.00 |
| 12:00:00 PM | 10.00 | 26.00 | 25.00 | 10.00 | 0.00 | 25.00 | 41.00 | 31.80 | 49.20 | 75.00 | 150.00 | 125.00 |
| 12:30:00 PM | 5.00 | 38.00 | 18.00 | 10.00 | 0.00 | 10.00 | 41.20 | 31.20 | 48.20 | 70.00 | 150.00 | 112.00 |
| 1:00:00 PM | 5.00 | 25.00 | 15.00 | 40.00 | 0.00 | 40.00 | 50.10 | 40.70 | 65.80 | 80.00 | 160.00 | 120.00 |
| 1:30:00 PM | 20.00 | 40.00 | 35.00 | 66.00 | 5.00 | 66.00 | 49.50 | 52.20 | 66.80 | 100.00 | 145.00 | 110.00 |
| 2:00:00 PM | 25.00 | 50.00 | 38.00 | 35.00 | 0.00 | 35.00 | 53.30 | 41.70 | 64.90 | 105.00 | 125.00 | 110.00 |
| 2:30:00 PM | 20.00 | 50.00 | 25.00 | 25.00 | 0.00 | 40.00 | 53.90 | 46.40 | 63.30 | 85.00 | 120.00 | 130.00 |
| 3:00:00 PM | 10.00 | 20.00 | 20.00 | 30.00 | 0.00 | 13.00 | 52.50 | 45.90 | 62.00 | 55.00 | 120.00 | 125.00 |
| 3:30:00 PM | 10.00 | 50.00 | 25.00 | 0.00 | 0.00 | 0.00 | 34.70 | 31.70 | 34.30 | 35.00 | 75.00 | 85.00 |
| 4:00:00 PM | 5.00 | 37.50 | 17.50 | 0.00 | 0.00 | 0.00 | 20.85 | 20.35 | 22.05 | 17.50 | 37.50 | 46.25 |
| 4:30:00 PM | 0.00 | 25.00 | 10.00 | 0.00 | 0.00 | 0.00 | 7.00 | 9.00 | 9.80 | 0.00 | 0.00 | 7.50 |
| 5:00:00 PM | 0.00 | 17.50 | 5.00 | 0.00 | 0.00 | 0.00 | 7.05 | 9.15 | 10.00 | 0.00 | 0.00 | 7.50 |
| 5:30:00 PM | 0.00 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.10 | 9.30 | 10.20 | 0.00 | 0.00 | 7.50 |
| 6:00:00 PM | 5.00 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.90 | 9.35 | 10.15 | 12.50 | 0.00 | 3.75 |
| 6:30:00 PM | 10.00 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.70 | 9.40 | 10.10 | 25.00 | 0.00 | 0.00 |
| 7:00:00 PM | 10.00 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.70 | 9.40 | 10.10 | 25.00 | 0.00 | 0.00 |
| 7:30:00 PM | 5.00 | 5.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.20 | 9.50 | 10.35 | 12.50 | 0.00 | 0.00 |
| 8:00:00 PM | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.70 | 9.60 | 10.60 | 0.00 | 0.00 | 0.00 |

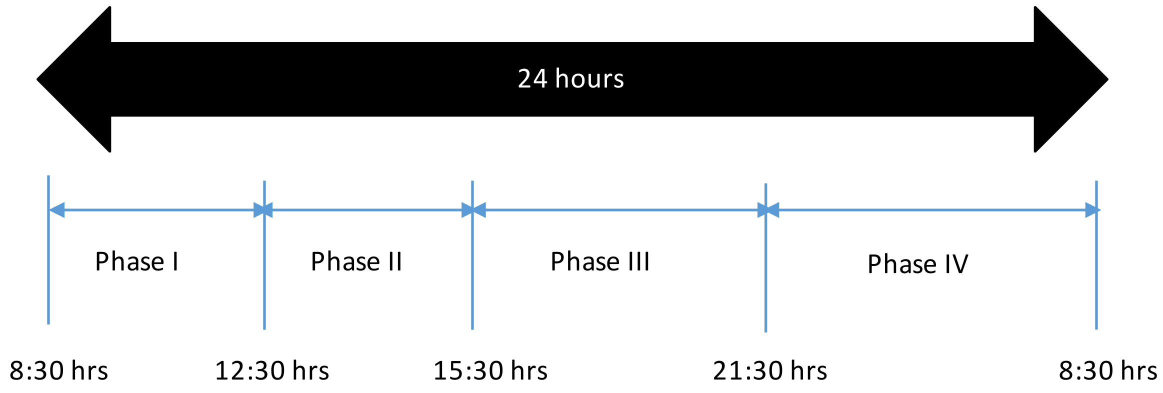
# Distribution Transformer Data

Period - ( 24 Hrs )

| Time Stamp | Panel 1 | | | Panel 2 | | | Panel 3 | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | TRANSFORMER 1 | | | TRANSFORMER 2 | | | TRANSFORMER 3 | | | |
| | R Phase | Y Phase | B Phase | R Phase | Y Phase | B Phase | R Phase | Y Phase | B Phase | |
| 9:00:00 AM | 138.00 | 173.00 | 173.00 | 200.00 | 30.00 | 225.00 | 322.10 | 338.70 | 312.10 | 1911.90 |
| 9:30:00 AM | 152.00 | 187.00 | 172.00 | 340.00 | 30.00 | 325.00 | 391.00 | 371.00 | 337.00 | 2305.00 |
| 10:00:00 AM | 169.00 | 237.00 | 183.00 | 210.00 | 120.00 | 235.00 | 394.90 | 372.00 | 357.40 | 2278.30 |
| 10:30:00 AM | 149.00 | 205.00 | 179.00 | 200.00 | 120.00 | 210.00 | 379.00 | 330.00 | 331.60 | 2103.60 |
| 11:00:00 AM | 143.00 | 218.00 | 175.00 | 200.00 | 80.00 | 200.00 | 378.00 | 328.00 | 337.00 | 2059.00 |
| 11:30:00 AM | 130.00 | 214.00 | 160.00 | 220.00 | 25.00 | 220.00 | 375.50 | 313.90 | 327.90 | 1986.30 |
| 12:00:00 PM | 162.00 | 244.00 | 206.00 | 190.00 | 10.00 | 200.00 | 365.70 | 321.40 | 322.30 | 2021.40 |
| 12:30:00 PM | 181.00 | 260.00 | 235.00 | 180.00 | 10.00 | 180.00 | 390.50 | 356.30 | 352.10 | 2144.90 |
| 1:00:00 PM | 206.00 | 230.00 | 245.00 | 200.00 | 20.00 | 200.00 | 385.10 | 388.00 | 368.80 | 2242.90 |
| 1:30:00 PM | 214.00 | 235.00 | 205.00 | 225.00 | 25.00 | 225.00 | 425.50 | 421.60 | 385.10 | 2361.20 |
| 2:00:00 PM | 256.00 | 252.00 | 240.00 | 210.00 | 15.00 | 215.00 | 372.60 | 365.70 | 318.60 | 2244.90 |
| 2:30:00 PM | 220.00 | 240.00 | 265.00 | 230.00 | 15.00 | 230.00 | 390.00 | 375.30 | 333.60 | 2298.90 |
| 3:00:00 PM | 205.00 | 227.00 | 246.00 | 210.00 | 20.00 | 240.00 | 367.20 | 372.00 | 334.00 | 2221.20 |
| 3:30:00 PM | 150.00 | 220.00 | 166.00 | 150.00 | 10.00 | 150.00 | 235.30 | 240.20 | 205.70 | 1527.20 |
| 4:00:00 PM | 98.50 | 140.00 | 122.00 | 125.00 | 10.00 | 135.00 | 159.20 | 156.50 | 139.55 | 1085.75 |
| 4:30:00 PM | 47.00 | 60.00 | 78.00 | 100.00 | 10.00 | 120.00 | 83.10 | 72.80 | 73.40 | 644.30 |
| 5:00:00 PM | 40.50 | 45.00 | 70.00 | 110.00 | 10.00 | 120.00 | 74.35 | 65.35 | 73.45 | 608.65 |
| 5:30:00 PM | 34.00 | 30.00 | 62.00 | 120.00 | 10.00 | 120.00 | 65.60 | 57.90 | 73.50 | 573.00 |
| 6:00:00 PM | 45.50 | 15.00 | 48.00 | 150.00 | 15.00 | 160.00 | 71.78 | 68.90 | 75.65 | 649.83 |
| 6:30:00 PM | 57.00 | 0.00 | 34.00 | 180.00 | 20.00 | 200.00 | 77.96 | 79.90 | 77.80 | 726.66 |
| 7:00:00 PM | 57.00 | 0.00 | 34.00 | 180.00 | 20.00 | 200.00 | 77.96 | 79.90 | 77.80 | 726.66 |
| 7:30:00 PM | 41.00 | 9.50 | 42.00 | 165.00 | 20.00 | 175.00 | 61.43 | 69.05 | 79.70 | 662.68 |
| 8:00:00 PM | 25.00 | 19.00 | 50.00 | 150.00 | 20.00 | 150.00 | 44.90 | 58.20 | 81.60 | 598.70 |

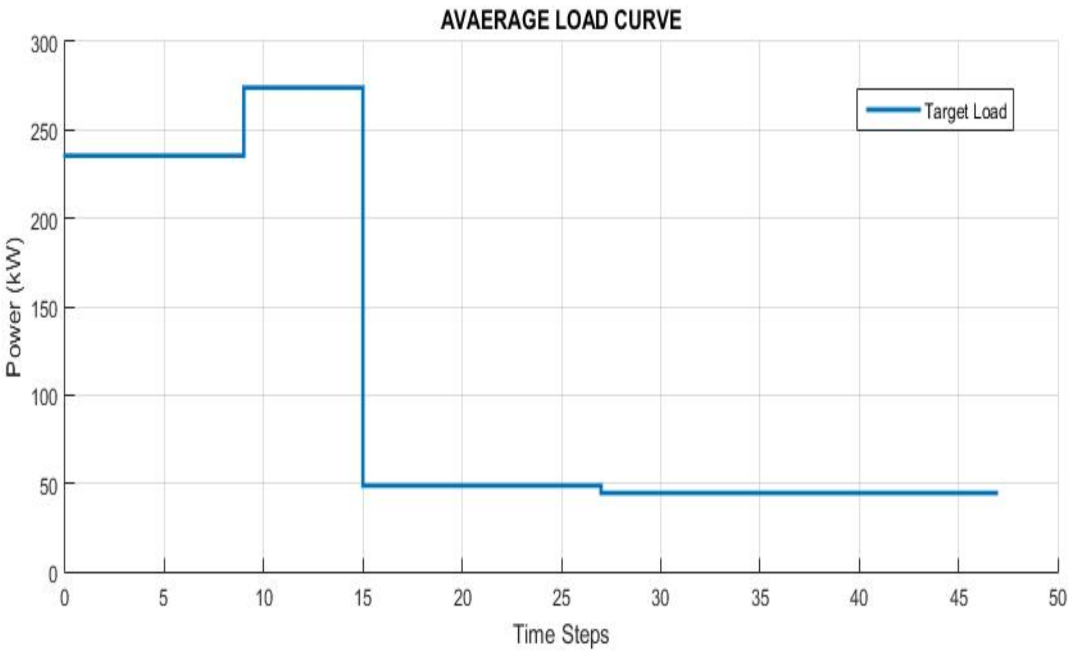
# Campus target load fixing

- Education institution follows flat tariff for electricity.
- Tracking dynamic pricing is difficult in this scenario, Hence, we divide the time period into four phases.
- For college campus objective curve is fixed by averaging the load for the given time period and the equation is,

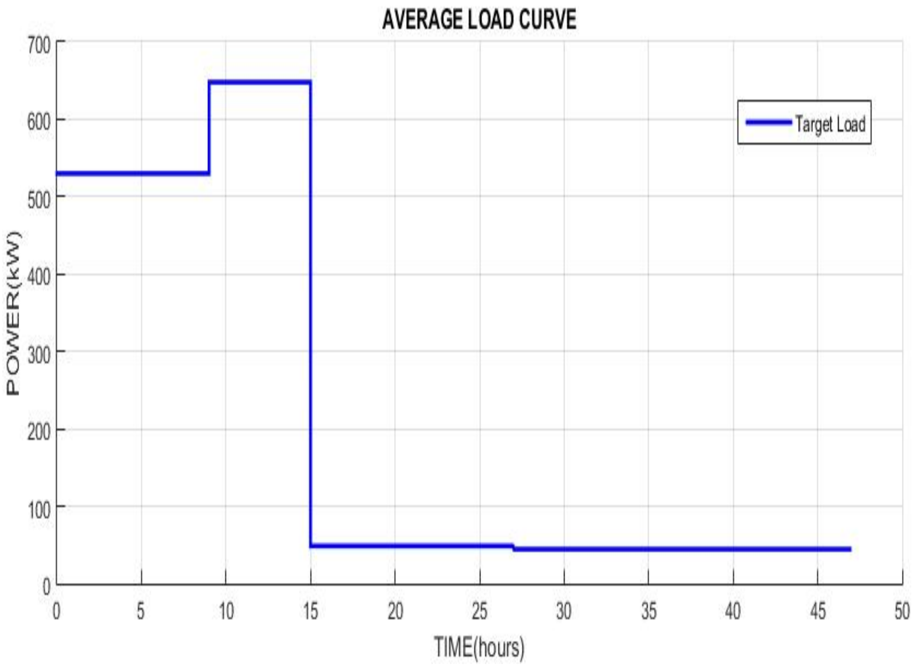



$$Objective(t) = \sum_{i=1}^{phases} Load\ factor(i) \times Maximum\ demand(i)$$

# Target load curves




Typical target load




Target Load during Peak demand hours

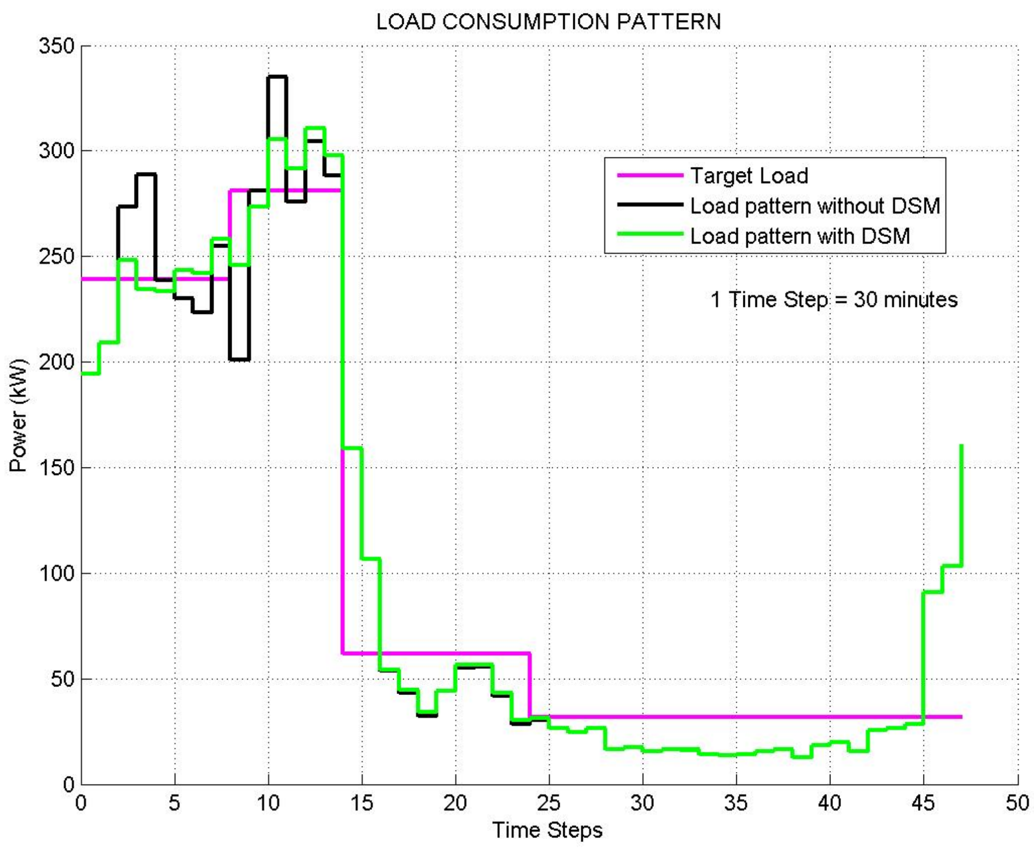
# CAMPUS DEMAND SIDE MANAGEMENT

IMPLEMENTATION

- SCENARIO 1 – Primary Supply alone
- SCENARIO 2 – DSM during peak demand hours
- SCENARIO 3 – Primary Supply with PV Integration
- SCENARIO 4 – DSM with PV during Peak demand hour
- SCENARIO 5 – Diesel Generator with PV Integration

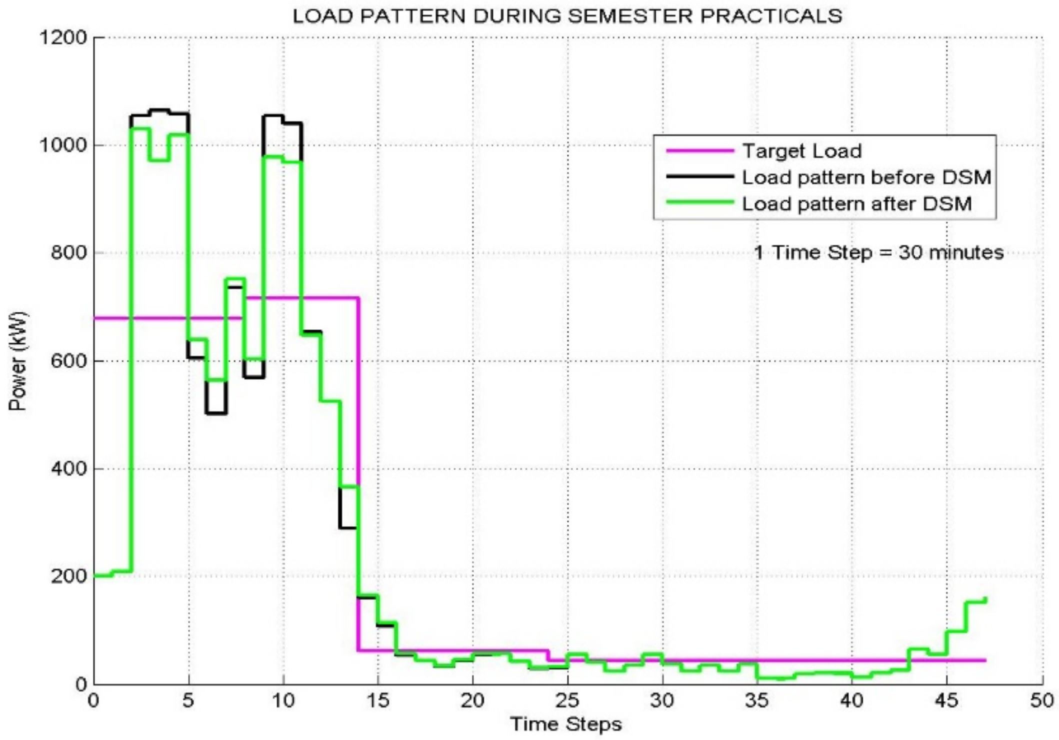
# SCENARIO 1: Primary Supply alone

- Simulations carried out for a system model powered solely by Primary power supply.
- This model excludes the existing solar panel and Diesel Generators.
- The results obtained on implementing DSM Strategy is shown in the graph.



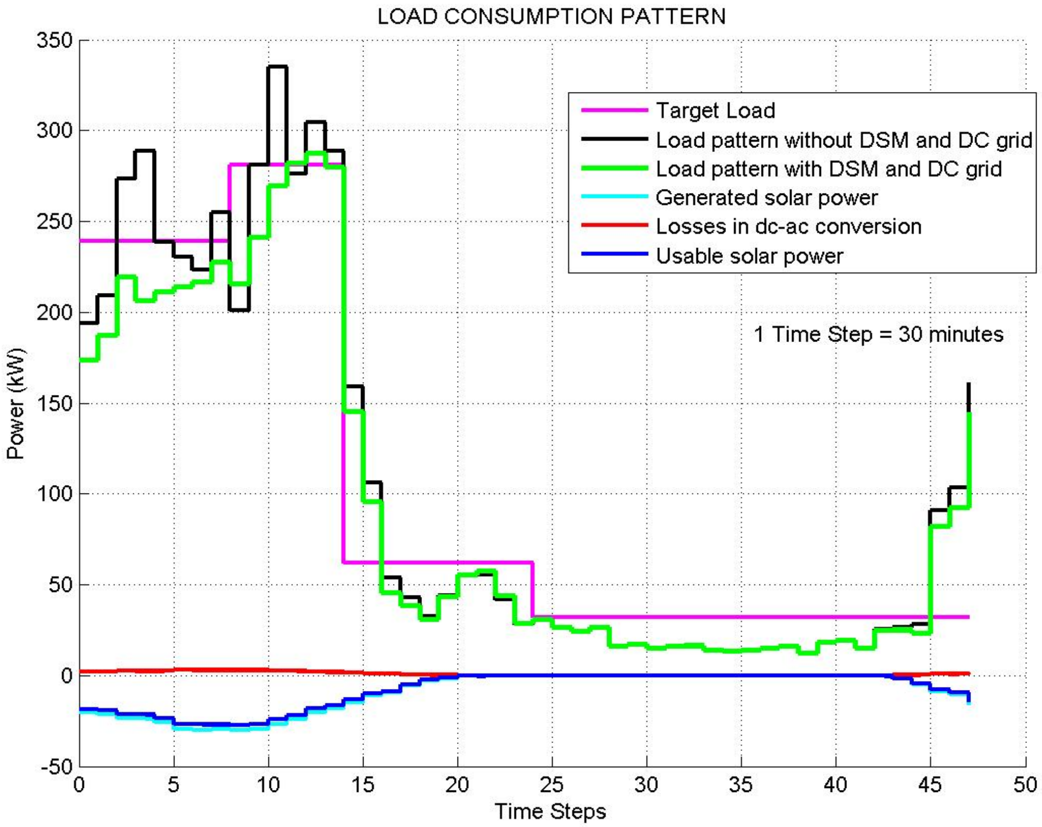
# SCENARIO 2: DSM during peak demand hours

- The maximum demand exceeds the permitted demand value, during end semester examinations.
- On doing so, penalty charges are added to the utility bill, which leads to hike in total consumption charge.



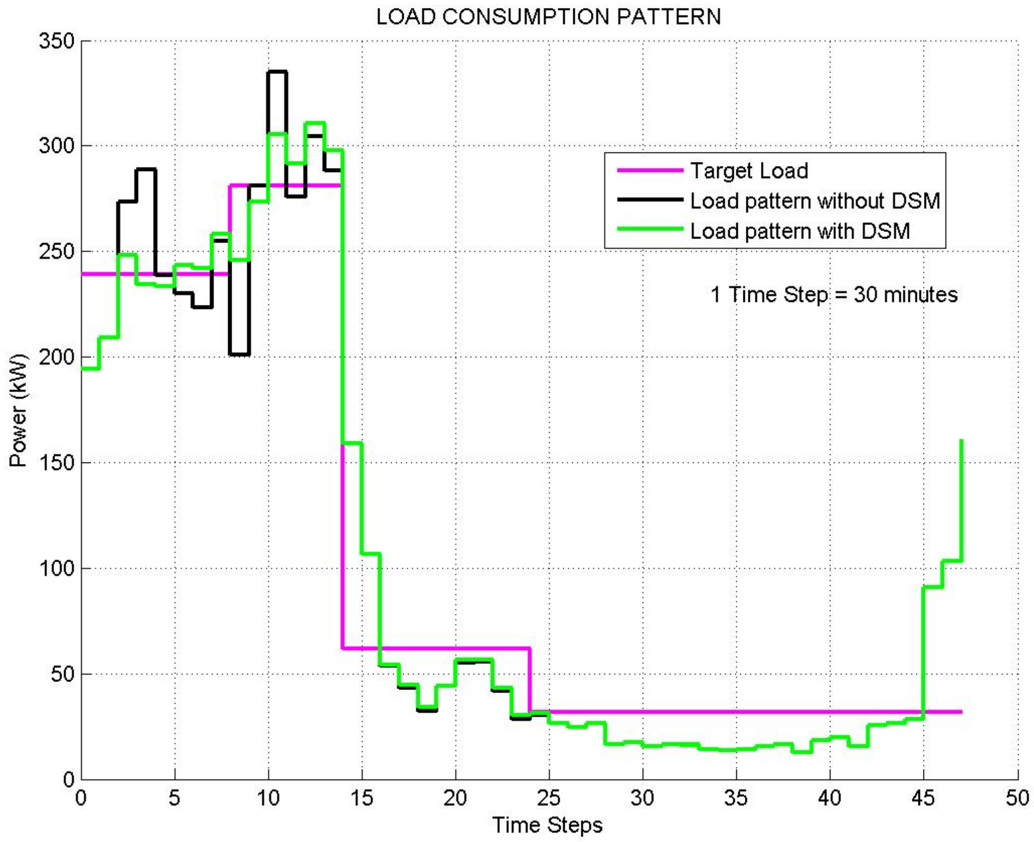
# SCENARIO 3: Primary Supply with PV Integration

- Simulations carried out for a system model powered by TNEB and existing 35kW PV Array.
- This model excludes the usage of existing diesel generators.
- The results obtained on implementing DSM Strategy is shown in the graph.



# SCENARIO 4: DSM with PV during Peak demand hour

- The scenario 3 is extended with solar integration and applied during peak demand hours.
- This usually occurs during the end semester examination. The results obtained are shown below



# SCENARIO 5: DG with PV Integration

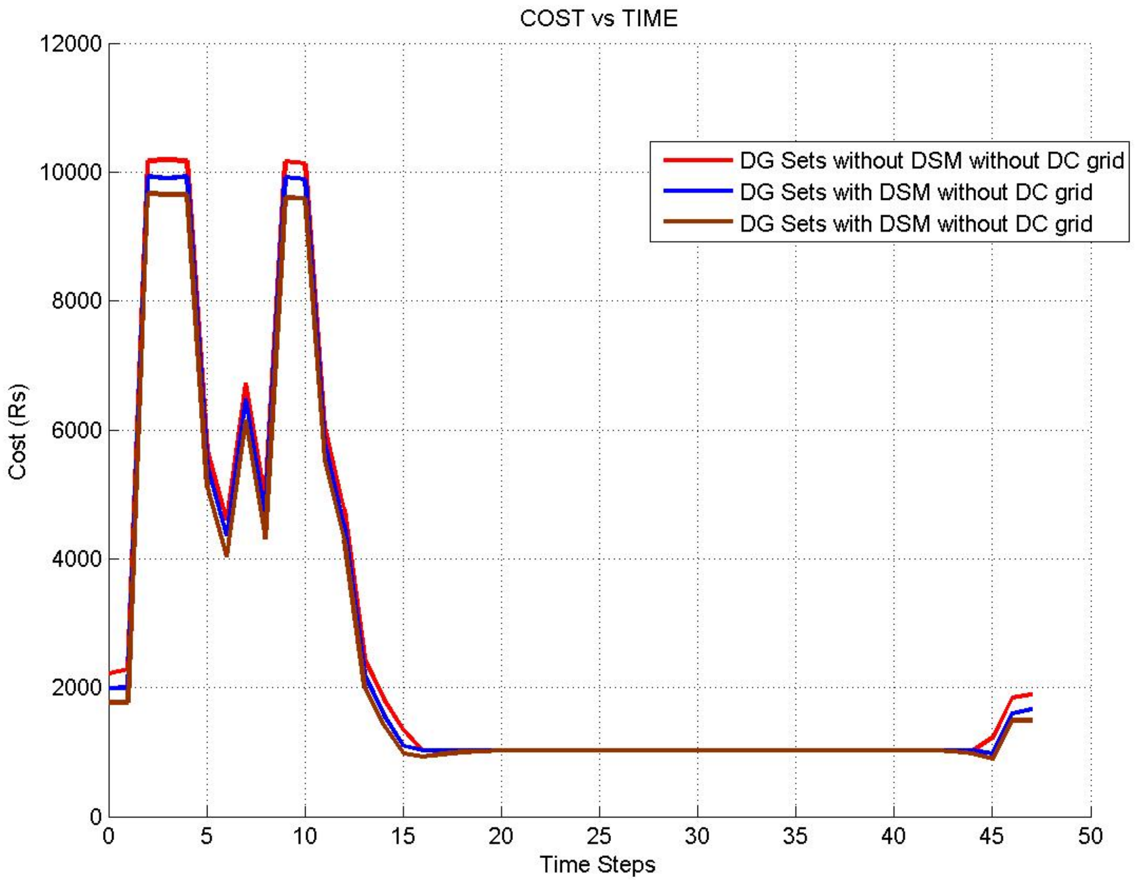
- For the optimal use of DG generator, unit commitment problem is solved and based on the demand, DG generators are scheduled.
- Full Load Average Production Cost

$$\boldsymbol{FLAPC = \frac{Fuel\,cost \times Fuel\,Consumed}{Power\;at\;Full\;load}}$$

| DG | FLAPC (Rs) | Base Charge (Rs) | Incremental cost (Rs) |
|---|---|---|---|
| 1 | 13.475 | 808.5 | 9.43 |
| 2 | 9.671 | 882 | 6.77 |
| 3 | 8.575 | 1029 | 6 |

- The commitment scheme would simply use only one of the following combinations as shown in table below.

| Combi-nation | MIN kW from combination | MAX kW from combination |
|---|---|---|
| 3+2+1 | 270 | 910 |
| 3+2 | 210 | 710 |
| 3 | 120 | 400 |



# Results

| | Peak Reduction in % | Cost reduction (Rs) | Cost reduction in % |
|---|---|---|---|
| **Non - Peak demand hours** | | | |
| Primary supply alone | 4.545 | nil | nil |
| Primary supply with PV Integration | 14.1184 | nil | nil |
| **Peak demand hours** | | | |
| Primary supply alone | 3.32 | 14,960.00 | 11.39 |
| Primary supply with PV Integration | 6.09 | 37,400.00 | 28.48 |
| DG with PV Integration | 5.762 | 4,699.00 | 3.65 |

# Conclusion

- The proposed strategy is a generalized technique based on load shifting, which has been mathematically formulated as a minimization problem.
- A heuristic based evolutionary algorithm is developed for solving the problem.
- The simulation outcomes carried out for a campus infrastructure shows that the proposed algorithm is able to handle a large number of controllable devices of several types, and achieves substantial savings while reducing the peak load demand.
- **Highlights :-**
  - Efficient allocation and usage of available DG Sets, which inturn reduces fuel cost, pollution, lifespan and maintenance.
  - Best utilization of existing 35kW Photovoltaic panels.
  - Support for future expansion of renewable assets.

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Thank You !!