INTERIM REPORT

ON

"Energy End Use" Study for Residential Electrical Equipments

Under the project titled as

Market Transformation of Energy Efficient Refrigerators and Air Conditioners

Submitted to

BUREAU OF ENERGY EFFICIENCY
New Delhi

By

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CONTENTS

1.0 PROJECT BACKGROUND:

BEE / UNDP on 16th April 2007 had awarded the Contract favouring TERI, Bangalore to conduct Energy End Use study for residential electrical equipment under the project **"Market Transformation for Energy Efficient Refrigerators & Air Conditioners",** along with the TOR & UNDP guideline.

The duration of the Contract was from 16th April 2007 to 15th April 2008, which was subsequently extended upto 30th November 2008 during July 2007.

The study covers energy consumption patterns of 'refrigerators and Air conditioners' of sampled houses at four Metros namely 'Delhi, Mumbai, Kolkatta and Bangalore' by using loggers for these two appliances which determines the pattern of energy and its operation itself. Of course, the energy usage at residential place for these two equipments is dependent on several factors such as

- Capacity of the equipments
- Number of persons
- Capacity utilization
- Income at household level etc.

2.0 PURPOSE OF THE PROJECT

- To collect important information at selected sample of houses on
  - ⇨ Pattern of actual baseline of electricity consumption
  - ⇨ Stock of electrical gadgets / appliances
    a) Refrigerators
    b) Air Conditioners
    c) Electrical appliances such as geyser, electrical iron, mixture, washing machine, computer, TV etc.
  - ⇨ Consumptive patterns at selected residential houses
  - ⇨ Degree of penetration of energy efficient appliances / devices
  - ⇨ Estimation of energy saving potential with respect to energy efficient appliances

3.0 METROS AND TYPE OF HOUSES FOR STUDY PURPOSE:

The study is for **50 houses** at each of the following four Metros, representing all socio-economic sections of the society.

- Delhi, Mumbai, Kolkata, Bangalore

Out of 50 houses, 20 houses to have 'data loggers' for capturing season-wise hourly 'energy data' for 30 days period for the following equipments and also temperature loggers to record room temperature on hourly basis:

- Refrigerators
- Air-Conditioners

Here 'energy data' includes kWhr and also operation cycle of the unit.

Balance 30 houses **instantaneous** measurements of electrical parameters such as voltage, current, pf, and kW loading of household electrical appliances. Further it was also decided to log the profile of energy consumptive pattern for TV at two Metro's for a month period at additionally selected 15 houses each at Delhi & Bangalore, totalling to 30 nos.

Further interactive / dialoguing survey research for 400 houses to be made at each Metro's based on various income groups.

4.0 CATEGORY OF RESIDENCES FOR STUDY:

As explained above, at each Metro, totally 450 nos of houses requires different category of study (3 varieties). Again these houses need to be classified to 'stratas' based on socio-economic characteristic directly as well as indirectly.

The study consists of three Categories with following requirements:

Category – 1: 20 houses to represent (Six strata) – 'Continuous measurements' i.e, profile of Electrical parameters for Refrigerator & Air Conditioners A separate electrical / temperature loggers to be installed at each houses were procured separately for this.

Category – 2: 30 houses to represent (Six strata) – 'Instantaneous measurements' of Electrical parameters for Electrical Appliances using plug-in type meter supplied by BEE

Category – 3: Survey data collection for 400 houses in the form of Questionnaires to represent four socio-economic strata. (100 houses in each socio-economic to include 10% of houses which do not have refrigerator or Air conditioner).

5.0 SAMPLING PLAN & FINALISATION OF CHOICE & DISTRIBUTION OF HOUSES BETWEEN EACH SECTOR CATEGORY:

As worked out in **Appendix 5.1 to 5.6**, highlights the procedure adopted in finalizing the 'sampling plan' for each of the six strata, thereby helped in deciding on choice and distribution of houses in each of the state / category 1, 2 & 3 for each of the metro. The outcome on final choice of houses for this study is listed below:

(A) For Category 1 & 2:

Strata	Category -1 No. of Houses selected				Category -2 No. of Houses selected			
	D	M	K	B	D	M	K	B
Independent double storey houses/bungalows	6	5	5	6	6	4	4	5
Flats (up to 4 story flats/buildings/apartments)	3	3	3	2	6	8	8	8
Multi-storey tower (> 4 story flats/buildings/apartments)	4	5	5	6	6	4	4	5
Housing Societies	3	2	2	2	3	3	3	2
Villages /city out skirts	2	3	3	2	3	3	3	2
Slums (Jagajeevanram	2	2	2	2	6	8	8	8

Colonies)								
Total	20	20	20	20	30	30	30	30

D: Delhi, **M:** Mumbai, **K:** Kolkata, **B:** Bangalore

(B) For Category– 3 Sample size & Distribution:

Strata	Category -3			
	No. of Houses selected			
	D	M	K	B
Very high income group	96	104	104	112
High income group	96	104	104	112
Middle income	128	104	104	112
Low income	80	88	88	64
Total	400	400	400	400

D: Delhi, **M:** Mumbai, **K:** Kolkata, **B:** Bangalore

6.0 DETAILS ON STUDY SEASONS / MONTHS

The study required for one month study for each of the four seasons spread over year's period. Based on the discussions held between BEE / TERI staff on 26th June 2008 at Bangalore, the following months were freezed as choice of the study:

METROS	Autumn	Winter	Spring	Summer
Delhi	Oct 07	Jan 07	Mar 08	Jun 08
Mumbai	Oct 07	Dec 07	Mar 08	May 08
Kolkata	Oct 07	Dec 07	Feb 08	May 08
Bangalore	Sep 07	Dec 07	Mar 08	Apr 08

A copy of break-up of activities and spread chart for the proposed study period is enclosed as **Appendix 6.1**

7.0 MEASUREMENTS METHODOLOGY:

7.1 Category-1: (20 residential houses at each metro for continuous profile of electrical parameters)

Single phase digital electrical data loggers were connected for **hourly** energy consumptive patterns of 30 days period to get load profile of loading & hours of usage for Air conditioners and Refrigerators. The electrical loggers have the following technical specifications:

- Class 1.0 accuracy
- Current range 5-30 A
- Built – in memory and real time clock circuitry, capability of load profile data.
- Display – LCD digital display.
- Downloading of data using software


Ambient temperature – Data loggers:

- Self contained battery powered having temperature range of 200C to 700C
- Temperature accuracy +/- 1^0C
- Storage capacity for 1 year data of 1 minute interval

7.2 Category – 2:

To use BEE supplied Single phase plug-in type digital data loggers for spot checking of following house hold electrical appliance:

- Television
- Computer
- Geysers
- Iron
- Kitchen appliances
- Washing machine
- Lighting load
- Ceiling fans

7.3 Observation on selection of household:

Getting different strata of house was tough task due to the following:

(i) At Mumbai flats and multi-storied buildings are very popular. As such getting an independent house was difficult.

(ii) In Bangalore independent house is very popular while getting a multi-storied building was a difficult. To get high raise buildings with 'Air Conditioner' was also a tough task, as Bangalore's weather do not call for this.

(iii) For installation of meters on Refrigerators and Air conditioners and multiple visits for measurements for Category – 2, there were difficulty due to the following problems:

- Respondent have an impression that their appliances would affect due to installation of meter.
- It affects their privacy
- Study teams visit would cause inconvenience to their privacy
- Some were of the opinion that it would cause additional energy consumption

- Also, some felt that there is some investigation going on at their home on electrical consumption and may lead a problem to them.
- They were of the fear that there would be objection by the Electricity board.

Inspite of explaining the objective etc., the people were not matured to support such studies, especially involving often visit to their place for measuring home appliances, which are spread throughout their home (bed rooms / kitchen, bath room).

7.4 Problems in getting the required type of logger meter:

In Indian market there are no suitable model which straightaway adopted for such study involving extensive logging to capture energy at an interval of one hour. There is limitation on memory. Also, arrangement for meter connection safety was a concern, requiring housing in a suitable outer cover. M/s Secure who supplied the loggers for this study had just then introduced i300 meter to the market.

There were many teething problems to incorporate the software suitable for our requirements. Problems also faced in down-loading the data from the meter to the computer, which were successfully solved by TERI team on constant interaction with the meter supplier.

8.0 DATA ON CATEGORY-1 HOUSEHOLDS FOR AUTUMN (OCT 07) AND WINTER MONTHS (DEC 07)

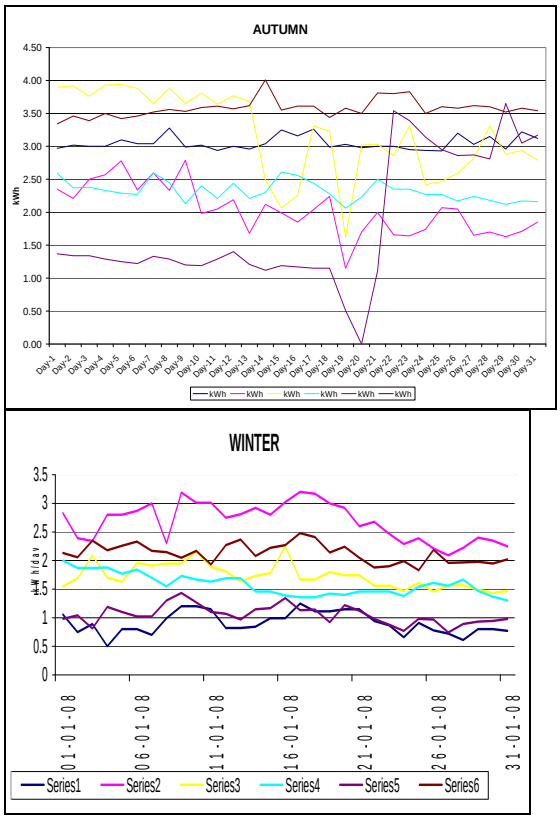
8.1 Delhi Metro:

The recorded values of data loggers for Refrigerators and Air Conditioners for 20 houses were down loaded and the hourly values hard copied for Autumn and Winter have been provided**.** The trends of daily energy consumption values for the two months, Strata - wise are depicted in the graph below:

(8.1.1) Strata – 1 (Independent House/Bungalow) – Refrigerators:

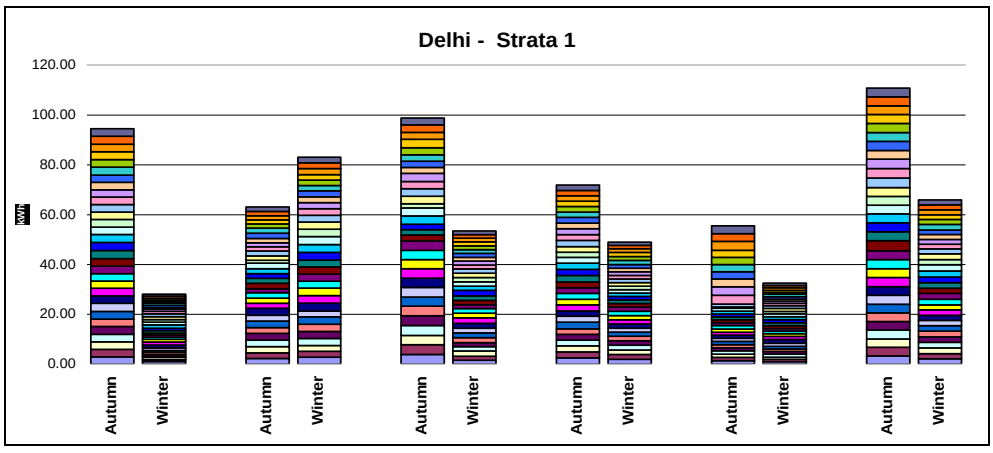
a) Daily energy consumptive profile of Refrigerators:

Strata – 1: Autumn (Refrigerator)
Strata – 1: Winter (Refrigerator)



Variation in daily energy consumption is higher during Autumn month.

b) The comparison of cumulative energy figures for the two seasons for strata – 1 is depicted in bar chart:



It can be seen that in case of five out of the six houses the monthly energy consumption for Refrigerator during winter months is less than autumn months. Monthly consumption varies from 28 Units to 110 units.

c) The seasonal energy consumptive figures of Air conditioners for Autumn and Winter months are tabulated below:

House ID	Autumn	Winter
	kWh / month	kWh / month
1	0.1	0
2	60	0
3	22	0
4	3	0
5	2	0
6	1	0

The consumption varies from 0.1 unit to 60 units in Autumn and nil in winter.

d) Statistical data of Strata – 1 for Autumn and Winter

Strata – 1: Autumn (Refrigerators)
Strata – 1: Winter (Refrigerator)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	82.48	14.45	380.30
Max	110.85	60.04	609.66
Min	55.55	0.10	245.94
SD	22.04	23.80	130.43
CV	0.27	1.65	0.34

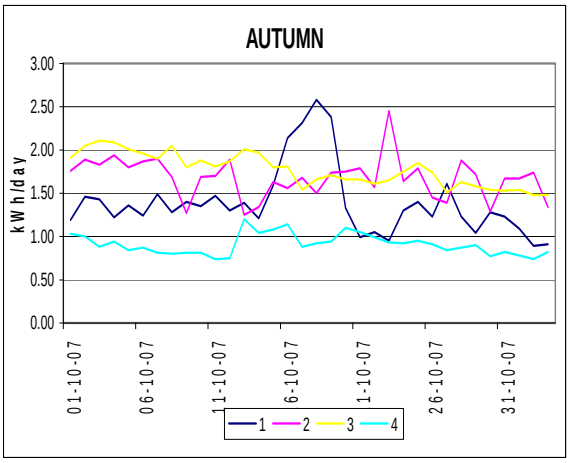
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
Mean	52.04	0.00	333.90
Max	83.08	0.00	585.38
Min	28.13	0.00	183.02
SD	20.59	0.00	144.49
CV	0.40	.	0.43

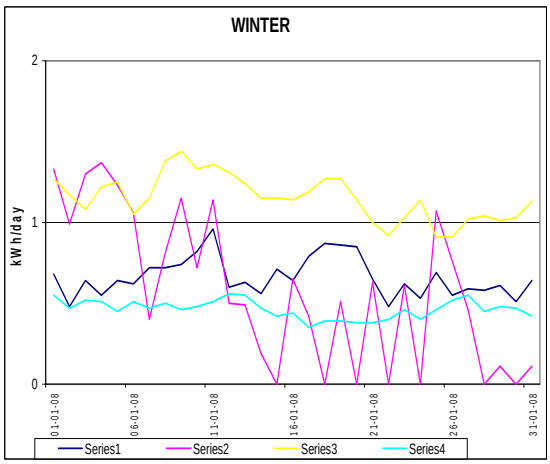
The mean value of Autumn for refrigerators is 58% higher than winter month. The Standard Deviation (scattered ness) for Autumn is slightly higher than Winter.

8.1.2 Strata – 2 (Flats)

a) Daily energy consumptive profile of Refrigerators:

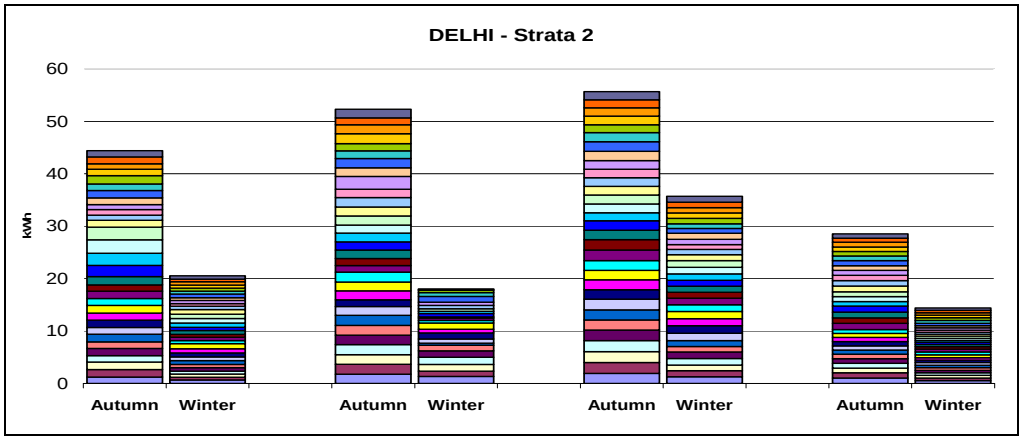
Strata – 2 : Autumn (Refrigerators)
Strata – 2: Winter (Refrigerator)





Variation in daily energy consumption is higher in winter month for one of the respondent and total energy consumption is lower in winter month.

b) The comparison of energy consumption for the two seasons for strata– 2 is depicted in bar chart:



All the four houses the monthly energy consumption for Refrigerator during winter months is less than autumn months. Monthly units vary from 13 units to 55 units.

c) The season energy consumptive figures of air conditioners for Autumn and Winter months are tabulated below:

House ID	Autumn	Winter
	kWh / month	kWh / month
7	0.01	0
8	0.2	0
9	0.07	0
10	4	0

There is nil consumption of AC both during Autumn and Winter.

d) Statistical data of Strata – 2 for Autumn and Winter

Strata – 2 : Autumn (Refrigerators & AC)

Statistics	Ref_ kWh_ autumn	AC _ kWh _ Autumn	Total Household_ kWh_ Autumn
Mean	45.23	1.09	233.67
Max	55.65	4.09	306.25
Min	28.53	0.01	155.81
SD	12.09	2.00	61.83
CV	0.27	1.84	0.26

Strata – 2: Winter (Refrigerator & AC)

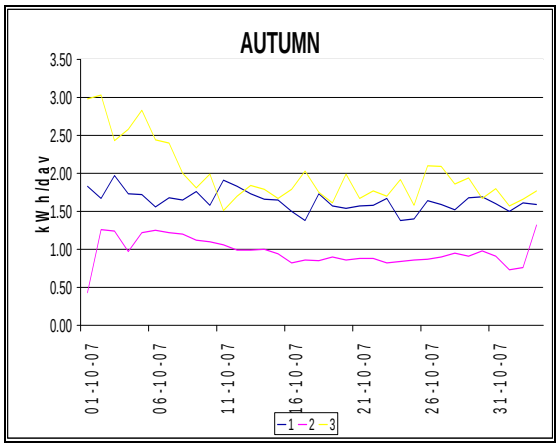
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household _ kWh_ Winter
Mean	22.15	0.00	210.85
Max	35.70	0.00	307.95
Min	14.37	0.00	115.74
SD	9.38	0.00	84.70
CV	0.42	.	0.40

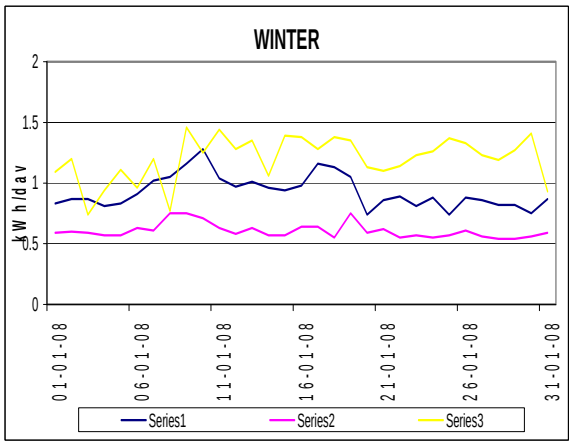
The mean value of Autumn for refrigerators is 104% higher than winter month. The Standard Deviation (scattered ness) for Autumn is higher than Winter.

8.1.3 Strata – 3 (Multi storied buildings):

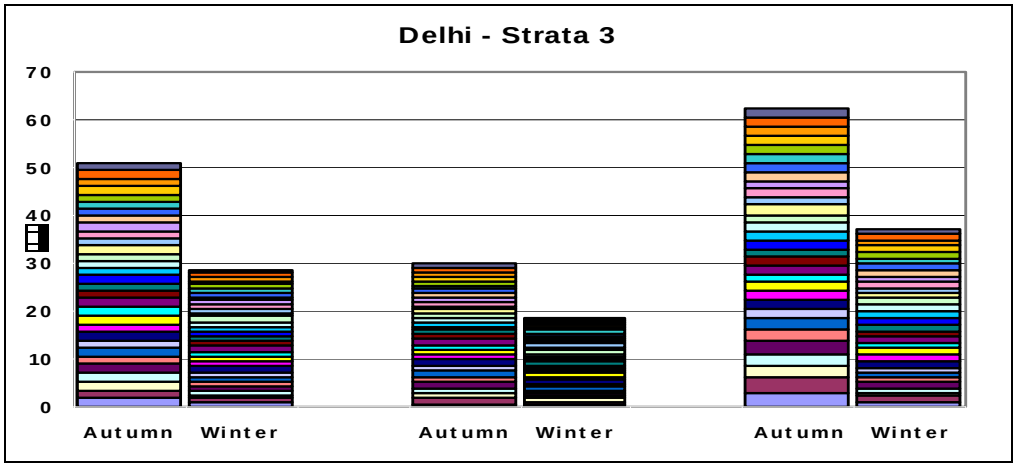
a) Daily energy consumptive profile of Refrigerators:

Strata – 3 : Autumn (Refrigerators)
Strata – 3: Winter (Refrigerator)





b) The comparison of energy figures for the two seasons for strata – 3 is depicted in bar chart:



For all the three houses the monthly energy consumption for Refrigerator during winter months is less than autumn months. Monthly energy consumption varies from 19 units to 82 units.

c) The seasonal energy consumptive figures of air conditioners for Autumn and Winter months are tabulated below:

House ID	Autumn	Winter
	kWh / month	kWh / month
11	0	0
12	0.85	0
13	0	0

Air conditioner energy consumption is nil for autumn and winter month.

d) Statistical data of Strata – 3 for autumn and winter

Strata – 3 : Autumn (Refrigerators & AC)
Strata – 3: Winter (Refrigerators & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	47.77	0.28	193.49
Max	62.27	0.85	230.71
Min	30.08	0.00	172.21
SD	16.33	0.49	32.34
CV	0.34	1.73	0.17

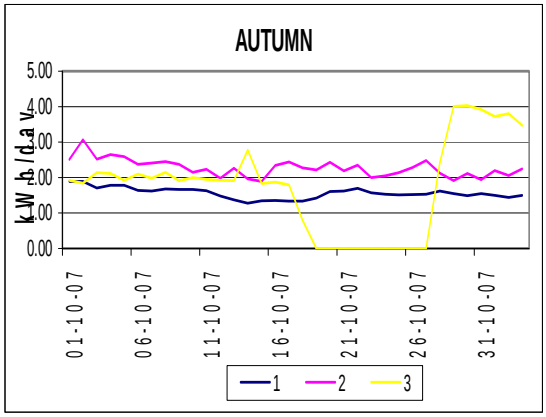
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household _ kWh_ Winter
Mean	28.26	0.00	177.41
Max	37.22	0.00	213.75
Min	18.78	0.00	135.15
SD	9.23	0.00	39.64
CV	0.33	.	0.22

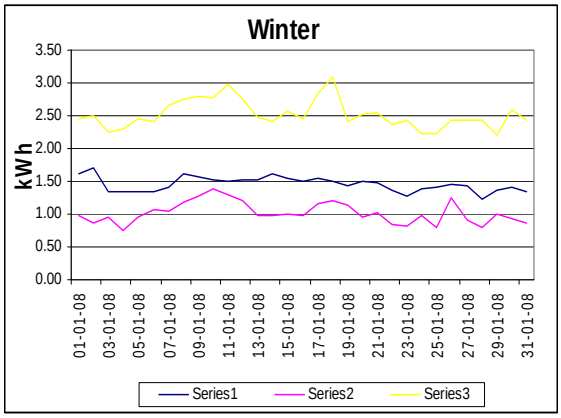
The mean value in autumn for Refrigerator is higher by 69% of winter month. The Standard Deviation is winter is less than autumn.

8.1.4 Strata – 4 (Society)

a) Daily energy consumptive profile of Refrigerators:

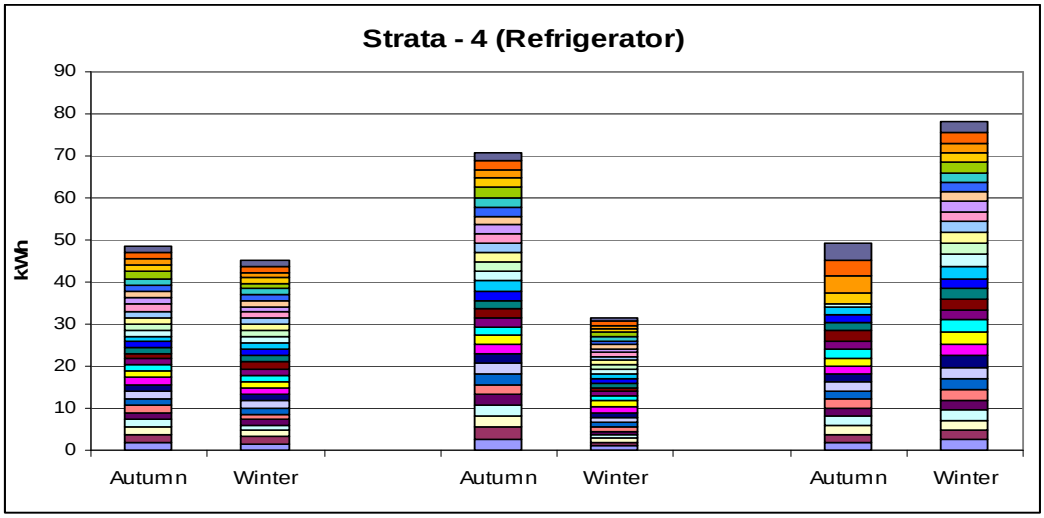
Strata – 4 : Autumn (Refrigerators)
Strata – 4: Winter (Refrigerator)





The total energy consumption has reduced in winter and trend almost uniform except one refrigerator.

b) The comparison of energy figures in respect of Refrigerators for the two seasons for strata – 4 is depicted in bar chart:



Out of three houses two houses monthly energy consumption for Refrigerator during winter months is higher than autumn month. Monthly energy consumption varies from 0 units to 78 units.

c) The seasonal energy consumptive figures of air conditioners for Autumn and Winter months are tabulated in the following table:

House ID	Autumn kWh / month	Winter kWh / month
14	0	0
15	0	1
16	0	0

There is no consumption both during Autumn and Winter.

d) Statistical data of Strata – 4 for autumn and winter

Strata – 4 : Autumn (Refrigerators & AC)
Strata – 4: Winter (Refrigerator & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	56.22	0.04	217.41
Max	70.71	0.06	278.92
Min	48.65	0.00	163.52
SD	12.56	0.03	58.07
CV	0.22	0.88	0.27

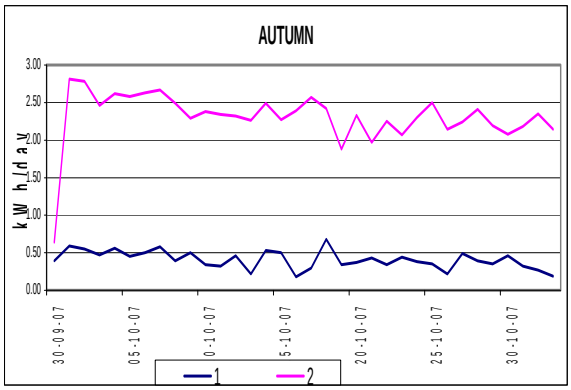
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winte
Mean	36.56	0.19	156.99
Max	78.12	0.57	223.68
Min	0.00	0.00	95.13
SD	39.30	0.33	64.41
CV	1.07	1.73	0.41

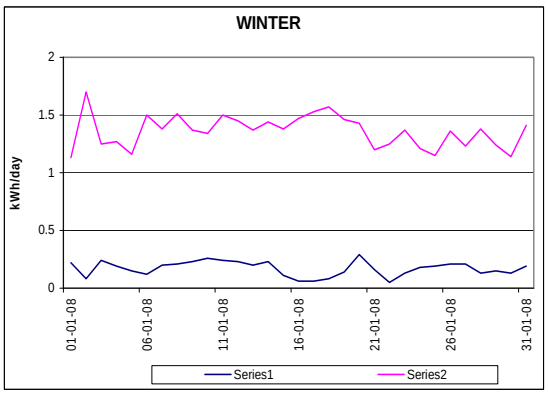
The overall mean value for winter is less than autumn month by 35%. The standard deviation for winter is high.

8.1.5 Strata – 5 (Village):

a) Daily energy consumptive profile of Refrigerators:

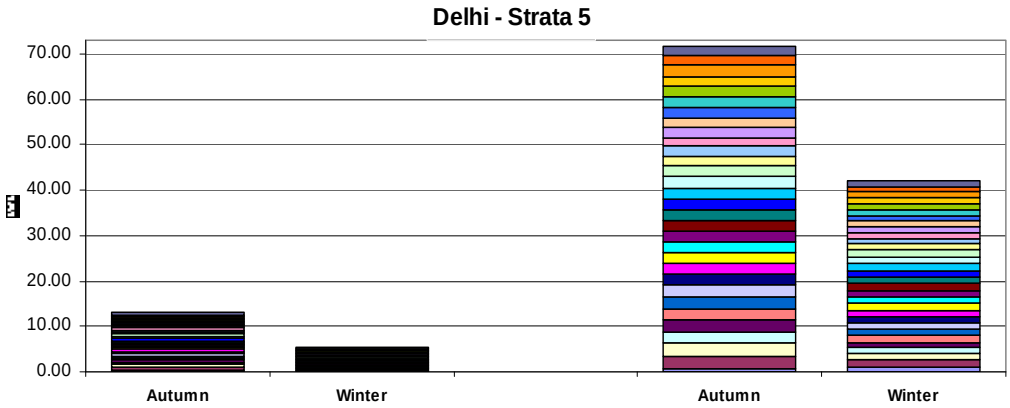
Strata – 5 : Autumn (Refrigerators)
Strata – 5: Winter (Refrigerator)





The trend is similar for both seasons with lesser energy consumption

b) The comparison of cumulative energy figures for the two seasons for strata – 5 is depicted in bar chart:



The monthly energy consumption for Refrigerator during winter months is less than autumn months. Monthly energy consumption varies from 5.27 units to 71.8 units.

c) Air Conditioner is not available for the strata.

d) Statistical Analysis of Strata – 5 for autumn and winter

Strata – 5 : Autumn (Refrigerators & AC)
Strata – 5: Winter (Refrigerator & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	42.42	AC not available	92.28
Max	71.77		101.22
Min	13.07		83.33
SD	41.51		12.65
CV	0.98		0.14

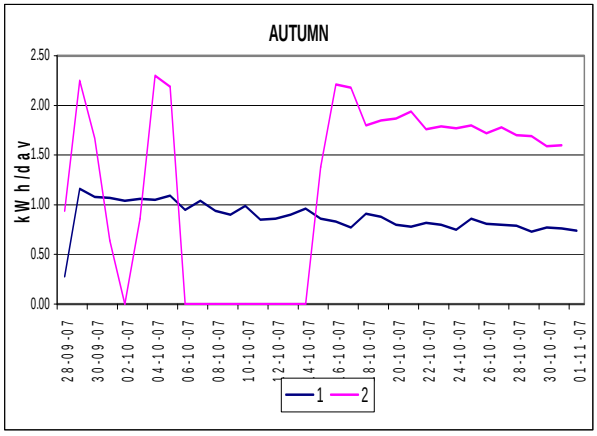
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
Mean	23.71	AC not available	42.10
Max	42.15		42.15
Min	5.27		42.05
SD	26.08		0.07
CV	1.10		0.00

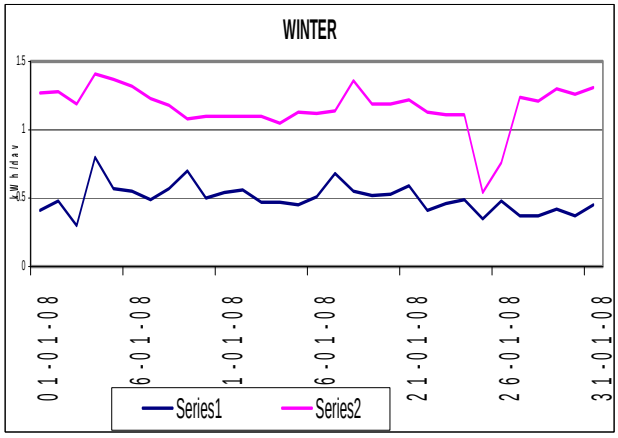
The overall mean value for winter is less than autumn month by 44%. The standard deviation for autumn is high. There wide variation in maximum to minimum energy consumption.

8.1.6 Strata – 6 (Slums)

a) Daily energy consumptive profile of Refrigerators:

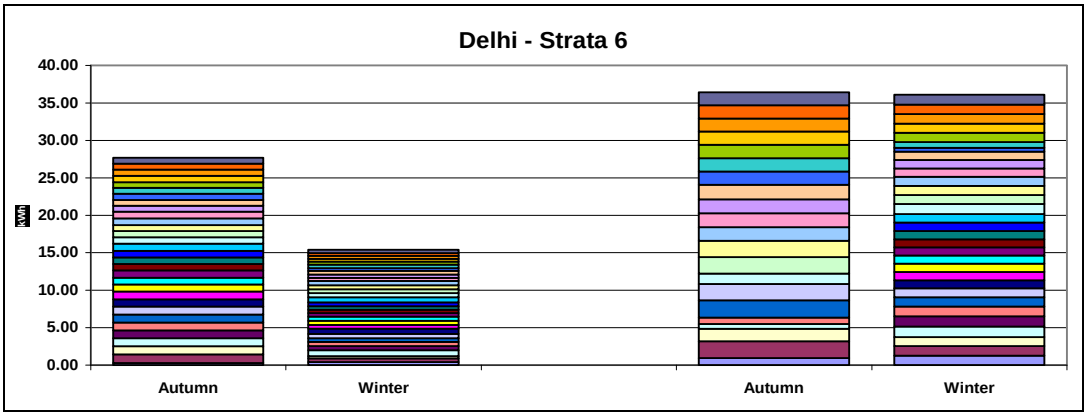
Strata – 6: Autumn (Refrigerators)
Strata – 6: Winter (Refrigerator





The trends are similar for both the seasons, energy consumption is lower for winter season.

b) The comparison of cumulative energy figures for the two seasons for strata – 6 is depicted in bar chart:



The monthly energy consumption for Refrigerator during winter months is less than Autumn months. Monthly energy consumption varies from 15.41 units to 36 units.

c) Air Conditioner is not available for the strata.

d) Statistical data of Strata – 6 for autumn and winter

Strata – 6 : Autumn (Refrigerators & AC)
Strata – 6 : Winter (Refrigerators & AC)

Statistics	Ref_ kWh_ autumn	AC _ kWh _ Autumn	Total Household_ kWh_ Winter
Mean	32.04	AC not available	66.74
Max	36.40		70.57
Min	27.68		62.92
SD	6.17		5.41
CV	0.19		0.08

Statistics	Ref_ kWh_ winter	AC _ kWh _ Winter	Total Household_ kWh_ Autumn
Mean	25.76	AC not available	115.81
Max	36.10		126.67
Min	15.41		104.95
SD	14.63		15.36
CV	0.57		0.13

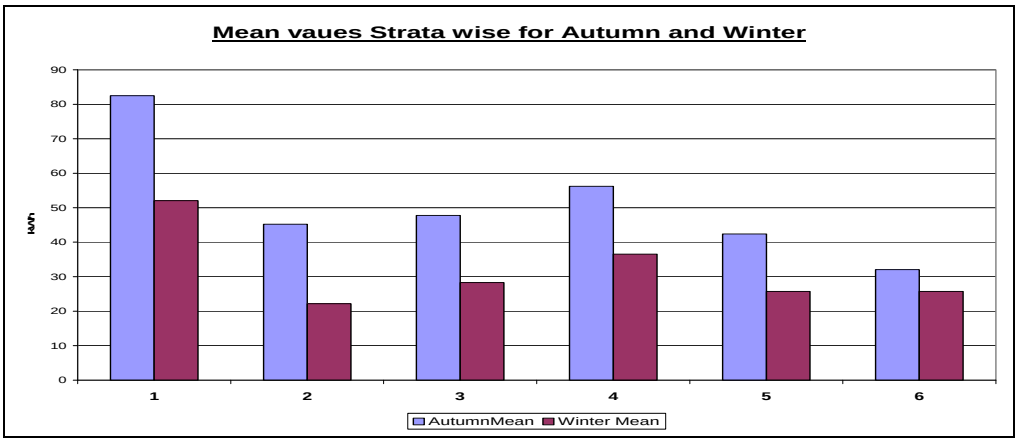
The overall mean value for winter is less than autumn month by 19%.The standard deviation for winter is higher than autumn.

*8.1.7 **Strata 1 to 6 (total)** Statistical data for all Strata for Autumn and Winter*

a) **Refrigerators - Energy profile in a nutshell**:

Strata	Autumn			Winter			Mean value % variation
	Mean	Max	Min	Mean	Max	Min	
	Urban						
1	82.48	110.85	55.55	52.04	83.08	28.13	37%
2	45.23	55.65	28.53	22.15	35.70	14.37	51%
3	47.77	62.27	30.08	28.26	37.22	18.78	41%
4	56.22	70.71	48.65	36.56	78.12	32.0	43%
	Rural						
5	42.42	71.77	13.07	25.76	36.10	15.41	39%
6	32.04	36.40	27.68	25.76	36.10	15.41	20%

- It is observed that the mean energy consumption in urban area is higher than the rural area.



As seen from the graph for mean value energy for all the six strata's winter month values are less than autumn month values.

b) **Statistical data for all strata together for Delhi:**

Autumn (Refrigerator & AC)
Winter (Refrigerator & AC)

Strata	Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household _ kWh_ Autumn
Total 1 to 6	N	20.00	20.00	20.00
	Mean	56.83	4.6	243.27
	Max	110.85	60.04	609.66
	Min	13.07	0	83.33
	SD	24.98	13.91	126.98
	CV	0.44	3.02	0.52

Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
N	20.00	20.00	20.00
Mean	34.71	0.03	243.27
Max	83.08	0.57	609.66
Min	0	0	83.33
SD	22.37	0.13	133.31
CV	0.64	4.47	0.66

There is wide variation between minimum to maximum energy consumption values. The standard deviation is observed to be high.

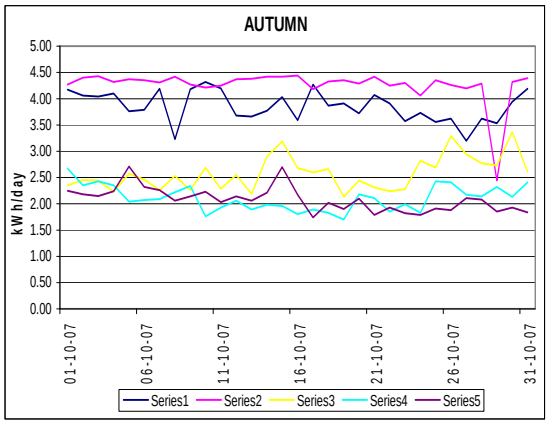
8.2 Mumbai Metro:

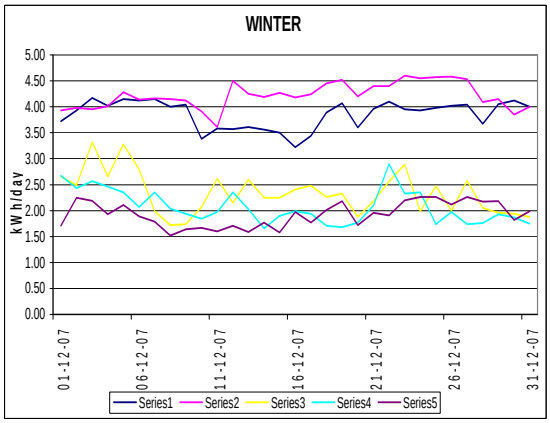
The recorded values of data loggers for Refrigerators and Air Conditioners for 20 houses were down loaded and the hourly values hard copied for autumn and winter have been provided**.** The trends of daily energy consumption values for the two months, Strata - wise are depicted in the graph below:

8.2.1 Strata – 1(Independent House/Bungalow)

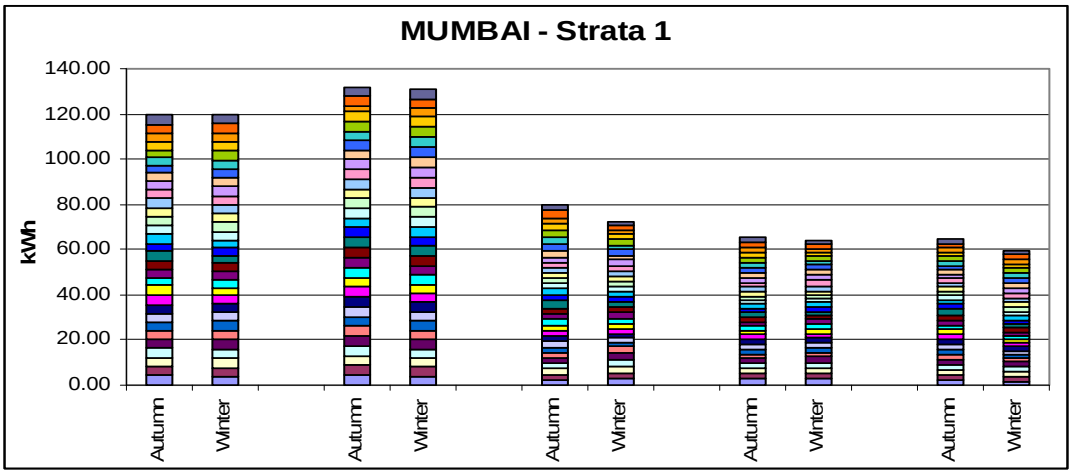
a) Daily energy consumptive profile of Refrigerators:

Strata – 1 : Autumn (Refrigerators)
Strata – 1 : Winter (Refrigerator)





b) The comparison of cumulative energy figures for the two seasons for strata–1 is depicted in bar chart:



There is not much difference in consumption between autumn and winter.

c) The seasonal energy consumptive figures of air conditioners for autumn and winter months are tabulated in the following table:

House ID	Autumn	Winter
	kWh / month	kWh / month
1	583	264
2	147	5
3	0	0
4	1	4
5	66	0

Except for house no. 1 other houses has very less consumption.

d) Statistical data for Strata-1 for autumn and winter

Strata – 1 : Autumn (Refrigerators & AC)
Strata – 1 : Winter (Refrigerator & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	91.91	159.21	512.8
Max	130.28	582.58	880
Min	64.54	0.00	276
SD	30.95	244.16	248.01
CV	0.34	1.53	0.48

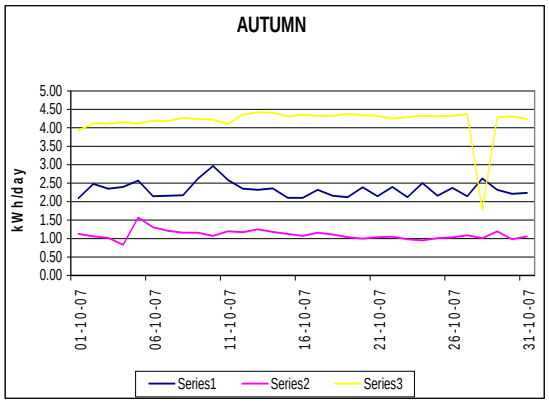
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
Mean	77.36	54.54	389.6
Max	130.76	263.58	650
Min	4.32	0.00	208
SD	50.75	116.88	177.06
CV	0.66	2.14	0.45

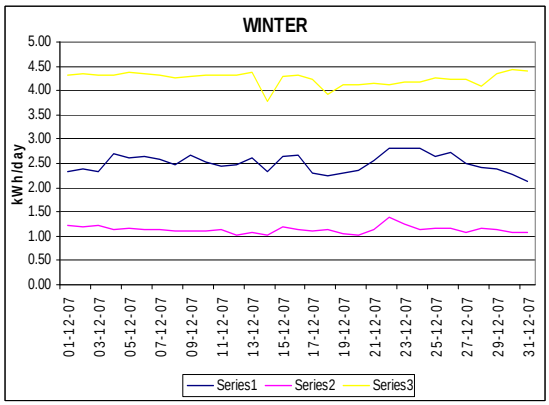
The standard deviation values for both season are very high. There wide variation between maximum to minimum values.

8.2.2 Strata – 2 (Flats)

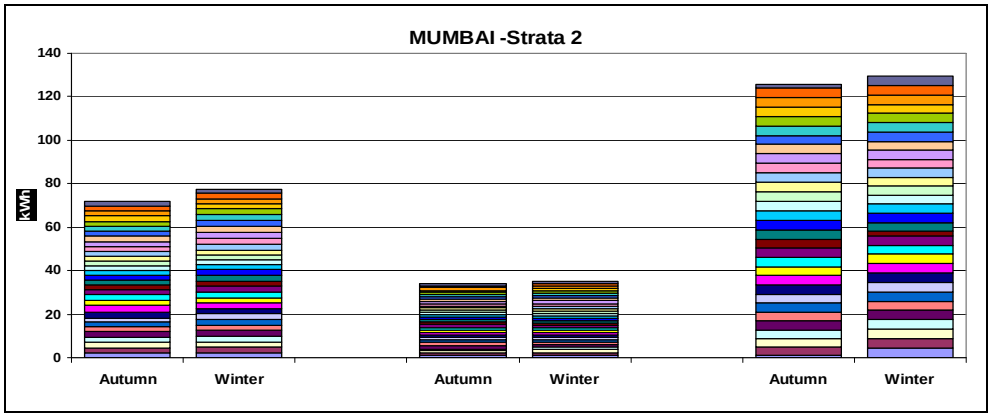
a) Daily energy consumptive profile of Refrigerators:

Strata – 2: Autumn (Refrigerators)
Strata – 2 : Winter (Refrigerator)





b) The comparison of cumulative energy figures for the two seasons for strata–2 is depicted in bar chart:



There is not much difference in total energy consumption in two seasons by Refrigerators. The total energy varies between 34kWh to 132 kWh.

c) The seasonal energy consumptive figures of air conditioners for autumn and winter months are tabulated in the following table:

House ID	Autumn	Winter
	kWh / month	kWh / month
6	198	71

7	0	0
8	131	0

There is some consumption of AC during autumn season.

d) Total Statistical Analysis for Strata-2 for Autumn and Winter

Strata – 2 : Autumn (Refrigerators & AC)
Strata – 2 : Winter (Refrigerator & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	77.33	109.52	346.00
Max	125.75	197.61	410.00
Min	34.21	0.05	267.00
SD	46.00	100.50	72.67
CV	0.59	0.92	0.21

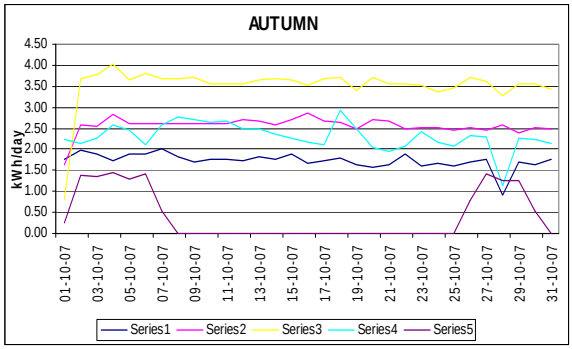
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household _ kWh_ Winter
Mean	80.84	23.52	328.3
Max	129.66	70.54	384.0
Min	35.19	0.00	291.0
SD	47.31	40.72	49.1
CV	0.59	1.73	0.15

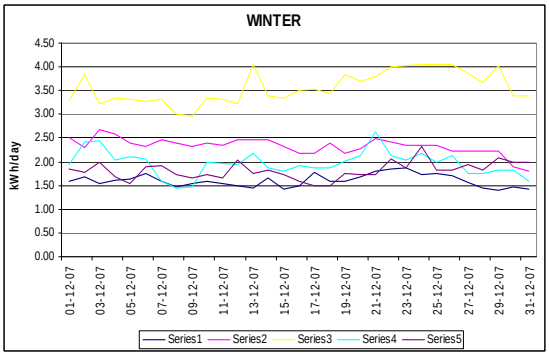
The Standard Deviation values are high for both the seasons.

8.2.3 Strata –3 (Multi-storied buildings):

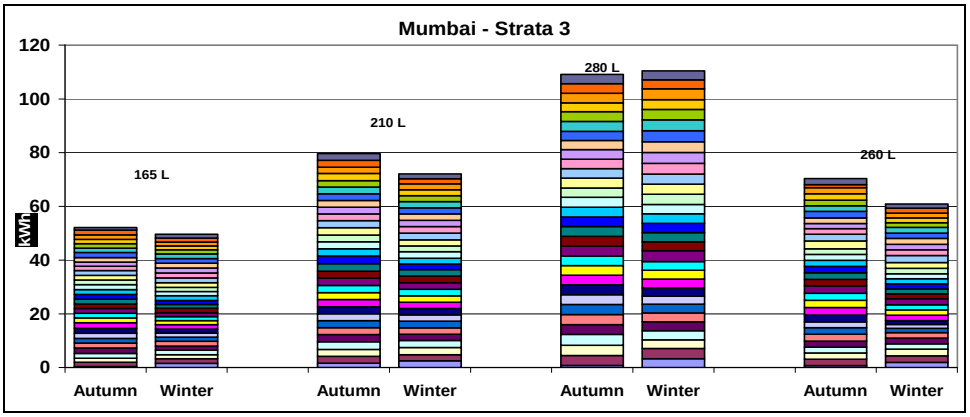
a) Daily energy consumptive profile of Refrigerators:

Strata – 3 : Autumn (Refrigerators)
Strata –3 : Winter (Refrigerator)





b) The comparison of cumulative energy figures for the two seasons for strata–2 is depicted in bar chart :



Three of the four houses monthly energy consumption for Refrigerator during winter months is higher than autumn months. The total energy ranges from 50 kWh to 110 kWh.

c) The seasonal energy consumptive figures of air conditioners for autumn and winter months are tabulated in the following table:

House ID	Autumn	Winter
	kWh / month	kWh / month
9	44	0.2
10	14	2
11	59	9
12	0	0

The consumption of Air conditioner is nil during winter.

d) Total Statistical Analysis for Strata-3 for autumn and winter:

Strata – 3 : Autumn (Refrigerators & AC)
Strata –3 : Winter (Refrigerator & AC)

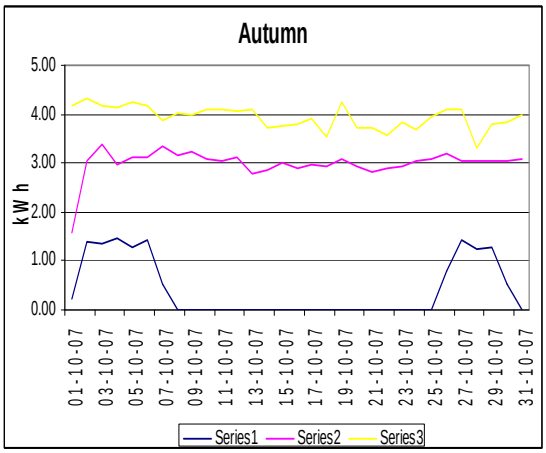
Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	61.271	17.998	325.5
Max	109.11	86.11	410
Min	6.78	0	245
SD	23.978	25.629	78.17
CV	0.3914	1.424	

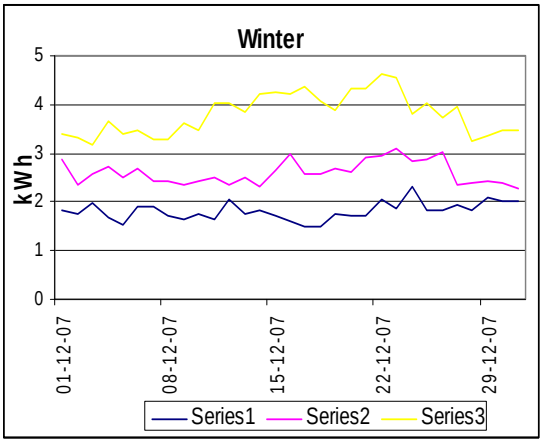
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household _ kWh_ Winter
Mean	50.58	0.73	316
Max	110.48	8.54	390
Min	15.24	0.00	240
SD	24.39	2.04	61.5
CV	0.48	2.80	

8.2.4 Strata –4 (Society):

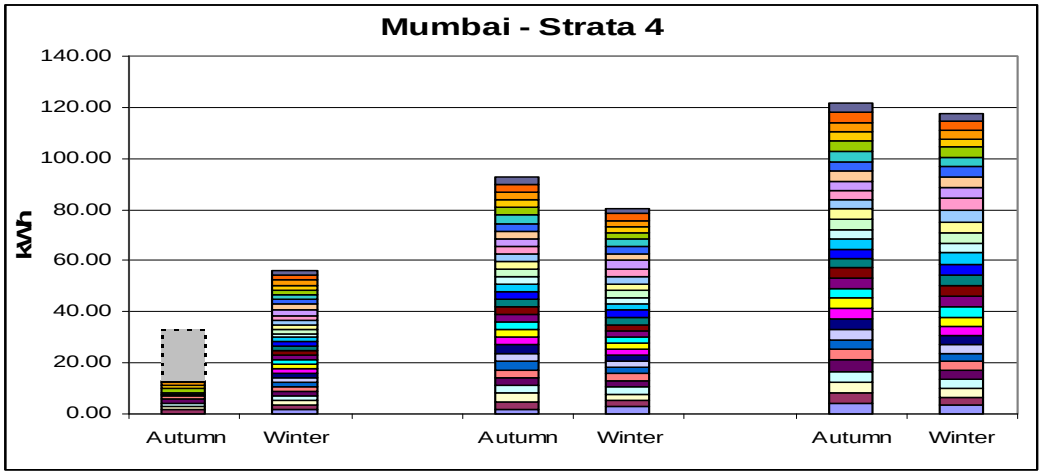
a) Daily energy consumptive profile of Refrigerators:

Strata – 4 : Autumn (Refrigerators)
Strata –4 : Winter (Refrigerator)





b) The comparison of cumulative energy figures for the two seasons for strata – 4 is depicted in bar chart:



Except one house the winter consumption is less than autumn month. First house has low energy consumption during autumn, which is due to nil consumption for 18 days (out of town). The total energy ranges from 10 kWh to 120 kWh.

c) The seasonal energy consumptive figures of air conditioners for autumn and winter months are tabulated in the following table:

House ID	Autumn	Winter
	kWh / month	kWh / month
13	74	1
14	12	1
15	100	39

d) Statistical data for Strata-4 for Autumn and Winter:

Strata – 4 : Autumn (Refrigerators & AC)
Strata –4 : Winter (Refrigerator & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	68.91	25.53	315.67
Max	119.60	100.47	470.00
Min	12.91	0.00	227.00
SD	33.32	37.74	134.15
CV	0.48	1.48	0.42

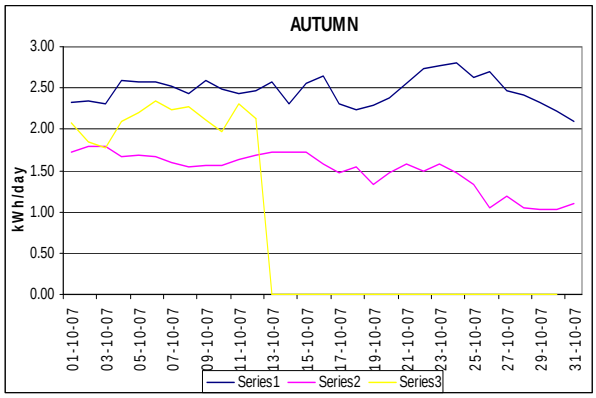
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household _ kWh_ Winter
Mean	61.71	4.20	298.67
Max	117.84	39.17	395.00
Min	0.00	0.00	242.00
SD	33.78	12.30	83.86
CV	0.55	2.92	0.28

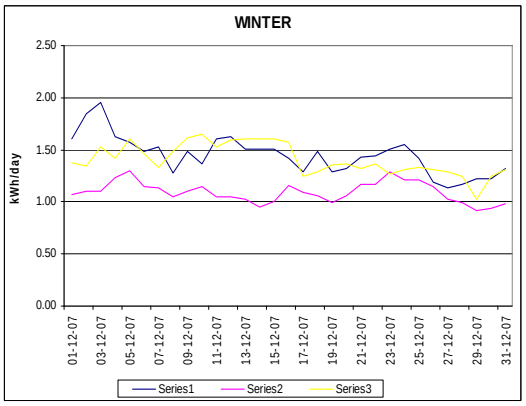
There is wide variation between maximum and minimum values. The SD is high for both seasons.

8.2.5 Strata –5 (Village)

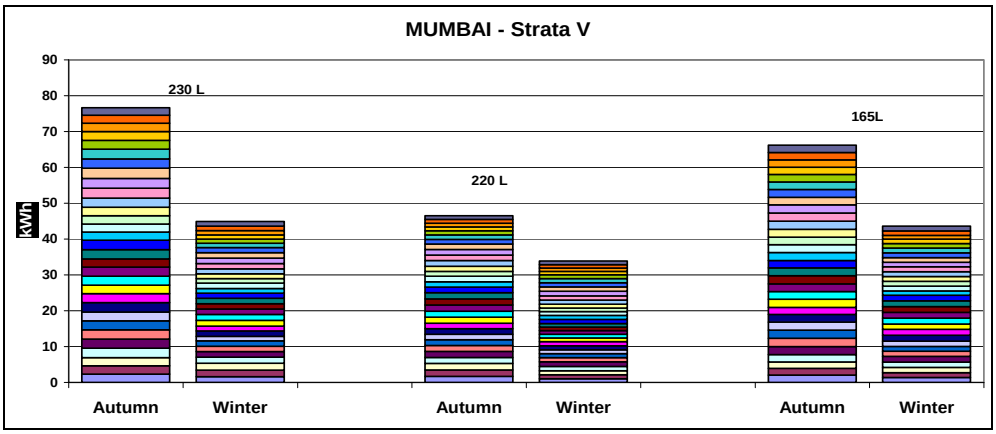
a) Daily energy consumptive profile of Refrigerators:

Strata – 5 : Autumn (Refrigerators)
Strata –5 : Winter (Refrigerator)





c) The comparison of cumulative energy figures for the two seasons for strata – 5 is depicted in bar chart:



The winter monthly energy is less than the autumn for all the houses. The energy consumption ranges from 34 kWh to 77 kWh.

c) Air Conditioner is not available for the strata.

d) Statistical data for Strata-5 for autumn and winter:

Strata –5 : Autumn (Refrigerators & AC)
Strata –5 : Winter (Refrigerator 7 AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	42.60	No AC under the category	63.15
Max	76.64		76.64
Min	13.07		46.58
SD	22.08		15.26
CV	0.52		0.24

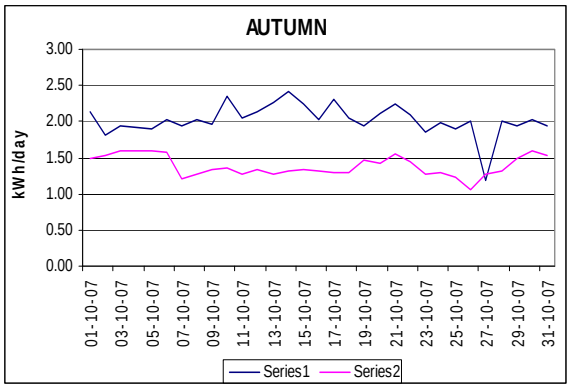
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
Mean	26.92	No AC under the category	179.67
Max	44.93		233.00
Min	5.27		125.00
SD	14.73		54.01
CV	0.55		0.30

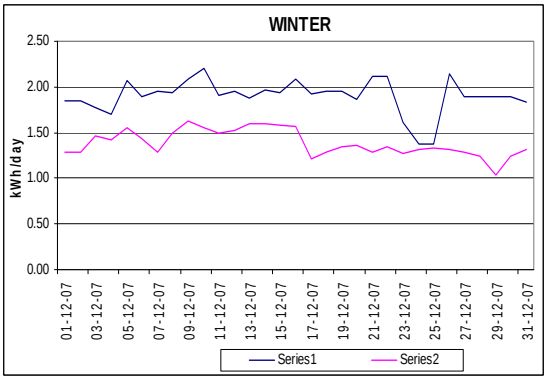
The standard deviation is moderate and lower during winter month.

8.2.6 Strata –6 (Slum)

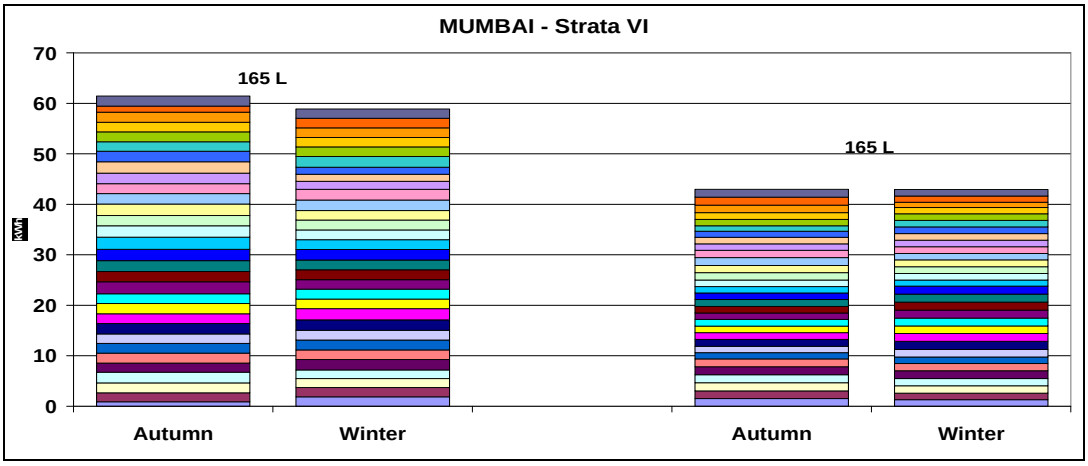
a) Daily energy consumption trend of Refrigerators:

Strata – 6 : Autumn (Refrigerators)
Strata –6 : Winter (Refrigerator





c) The comparison of cumulative energy figures for the two seasons for strata – 6 is depicted in bar chart:



The monthly energy is almost same for both the seasons. The energy consumption ranges from 43 kWh to 63 kWh.

c) There is no Air Conditioner available for the strata.

d) Statistical data for Strata-6 for autumn and winter:

Strata – 6 : Autumn (Refrigerators & AC)
Strata –6 : Winter (Refrigerators & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	36.48	No AC under the category	52.21
Max	61.45		61.45
Min	24.99		42.96
SD	11.84		13.07
CV	0.32		0.25

Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
Mean	30.68	No AC under the category	176.00
Max	58.87		202.00
Min	15.41		150.00
SD	14.84		36.77
CV	0.48		0.21

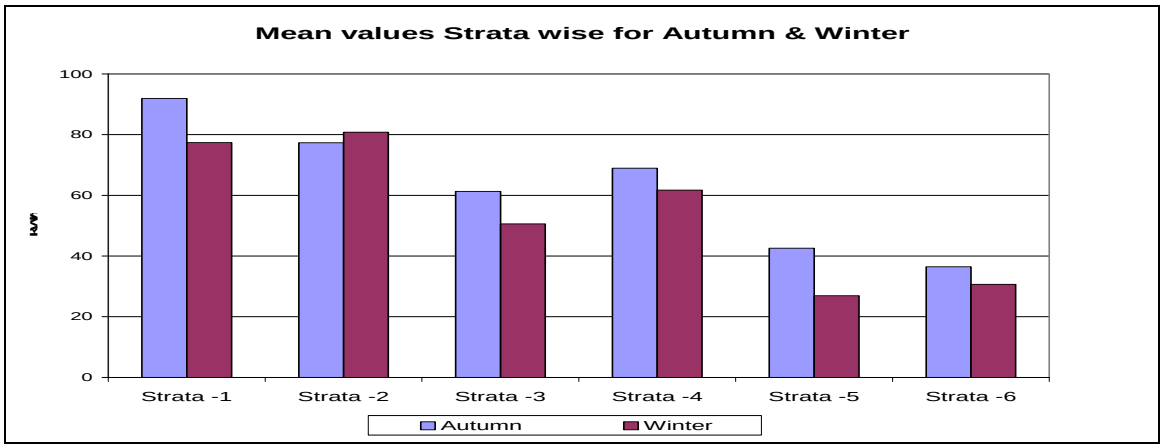
8.2.7 Strata 1 to 6 (total) *- Statistical data for all stratas for autumn and winter*

a) **Refrigerators - Energy profile in a nutshell**:

Strata	Autumn			Winter			% difference in Mean value
	Mean	Max	Min	Mean	Max	Min	
	Urban strata						
1	91.91	130.28	64.54	77.36	130.76	4.32	15.8
2	77.33	125.75	34.21	80.84	129.66	35.19	-4.5
3	61.271	109.11	6.78	50.58	110.48	15.24	17.4
4	68.91	119.60	12.91	61.71	117.84	0.00	10.4
	Rural strata						
5	42.60	76.64	13.07	26.92	44.93	5.27	36.8
6	36.48	61.45	24.99	30.68	58.87	15.41	15.9

- It can be observed that mean values for urban strata is higher than the rural strata.

Mean values of autumn and winter is depicted in bar chart. It can be seen that except for stata-2 other strata's winter month values are lower than autumn values.



b) **Statistical data for all strata together for Delhi:**

Total Autumn (Refrigerators & AC)
Total Winter (Refrigerators & AC)

strata	Statistics	AC_ kWh_ autumn	Ref_ kWh_ autumn	Total Household_ kWh_ Autumn
Total 1 to 6	N	20	20	343.30
	Mean	71.38	76.10	880.00
	Max	582.58	130.28	148.00
	Min	0.00	12.91	172.40
	SD	133.92	32.02	0.50
	CV	1.88	0.42	343.30

Statistics	AC_ kWh_ winter	Ref _ Kwh _ Winter	Total Household_ kWh_ Winter
N	20	20	299.20
Mean	19.78	70.07	650.00
Max	263.58	130.76	125.00
Min	0.00	4.32	121.52
SD	59.95	35.26	0.41
CV	3.03	0.50	299.20

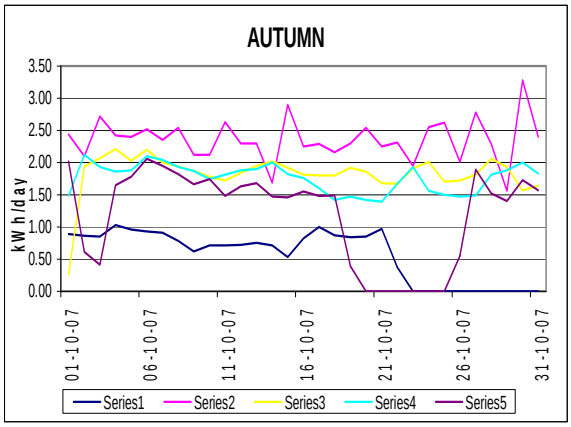
8.3 Kolkata Metro:

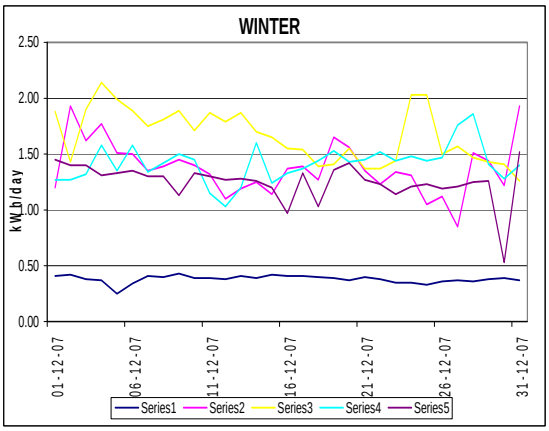
The recorded values of data loggers for Refrigerators and Air Conditioners for 20 houses were down loaded and hard copies of the hourly values for autumn and winter have been provided**.** The trends of daily energy consumption values for the two months, Strata wise are depicted in the graph below:

8.3.1 Strata – 1(Independent House/Bungalow):

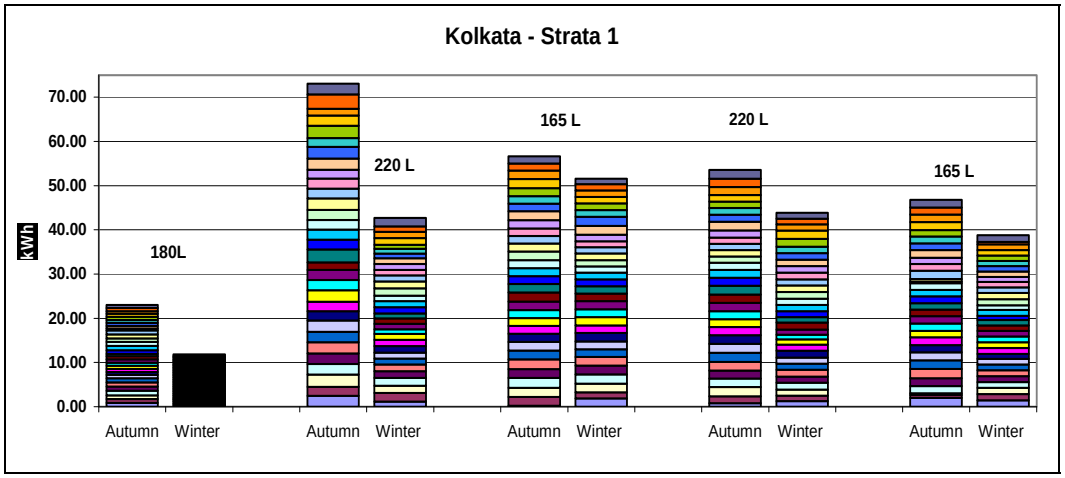
a) Daily energy consumptive profile of Refrigerators:

Strata – 1 : Autumn (Refrigerators)
Strata –1 : Winter (Refrigerator)





b) The comparison of energy consumption for the two seasons for strata – 1 is depicted in bar chart:



The monthly energy for winter seasons is lesser than autumn season. The energy consumption ranges from 12 kWh to 73 kWh.

c) The seasonal energy consumptive figures of air conditioners for autumn and Winter months are tabulated below:

House ID	Autumn	Winter
	kWh / month	kWh / month
1	55	0
2	157	0
3	87	0
4	19	0
5	14	0

Some consumption observed during autumn month.

d) Statistical Analysis of Strata – 1 for autumn and winter

Strata – 1: Autumn (Refrigerators & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	50.63	66.34	319.71
Max	73.09	156.78	535.68
Min	23.03	14.10	166.75
SD	18.20	58.61	168.31
CV	0.36	0.88	0.53

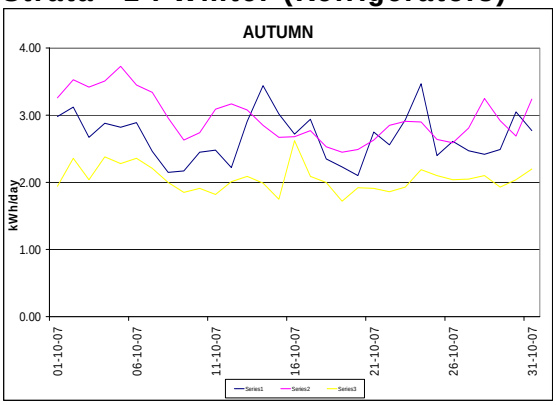
Strata –1 : Winter (Refrigerators & AC)

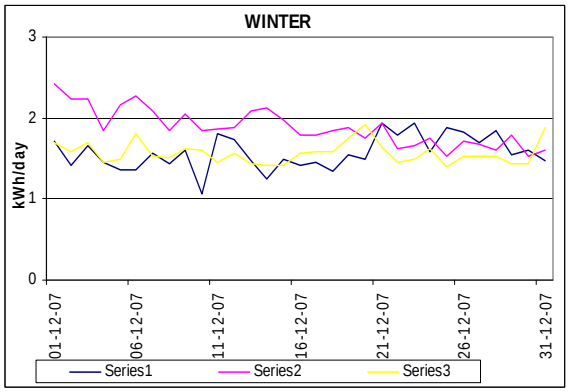
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household _ kWh_ Winter
Mean	37.76	0.00	249.12
Max	51.59	0.00	488.85
Min	11.81	0.00	129.73
SD	15.23	0.00	162.42
CV	0.40	.	0.65

8.3.2 Strata – 2 (Flats):

a) Daily energy consumptive figures of Refrigerators:

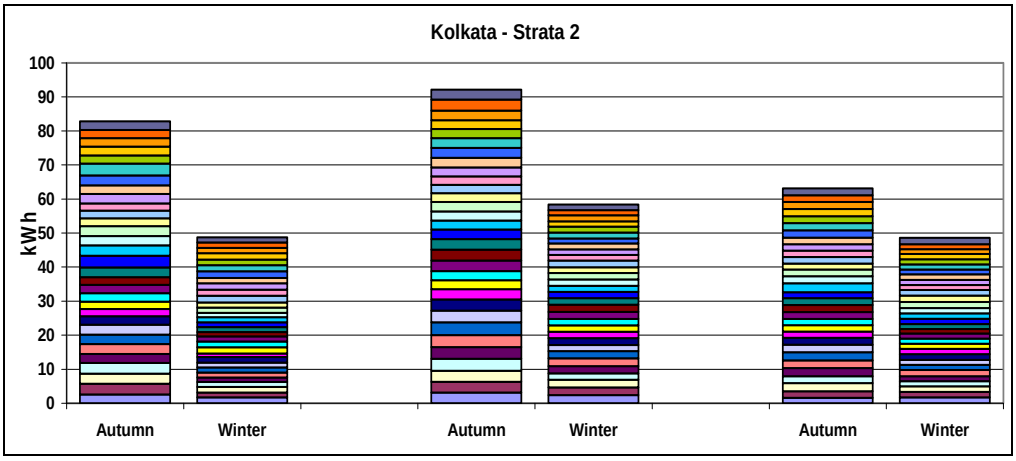
Strata – 2 : Autumn (Refrigerators)
Strata –2 : Winter (Refrigerators)





The trend is similar with lower energy consumption in winter.

b) The comparison of cumulative energy consumptive figure for the two seasons for strata– 2 is depicted in bar chart:



The monthly energy for winter season is lesser than autumn season. The energy consumption ranges from 49 kWh to 92 kWh.

c) The seasonal energy consumptive figure of air conditioners for Autumn and Winter months are tabulated below:

House ID	Autumn	Winter
	kWh / month	kWh / month
6	10	0.02
7	103	0
8	94	0
9	79	7
10	30	0

Some consumption observed during autumn month.

d) Statistical Analysis of Strata – 2 for autumn and winter

Strata – 2 : Autumn (Refrigerators & AC)
Strata –2 : Winter (Refrigerators & AC)

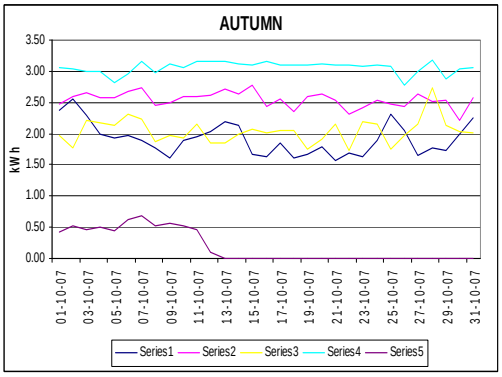
Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	79.35	105.45	389.41
Max	92.13	173.43	490.12
Min	63.1	29.92	207.41
SD	14.82	72.05	157.92
CV	0.19	0.68	0.41

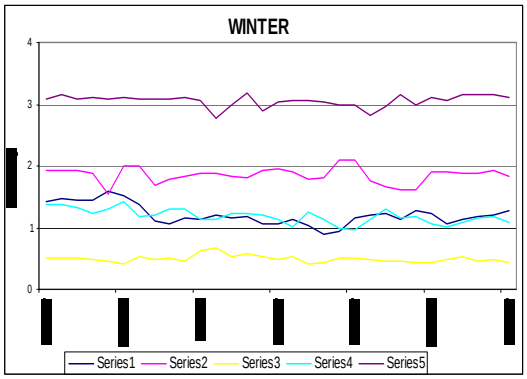
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household _ kWh_ Winter
Mean	51.89	2.40	333.40
Max	58.38	7.18	398.00
Min	48.57	0	246.66
SD	5.62	4.14	78.06
CV	0.11	1.72	0.23

8.3.3 Strata – 3 (Multi-storied building):

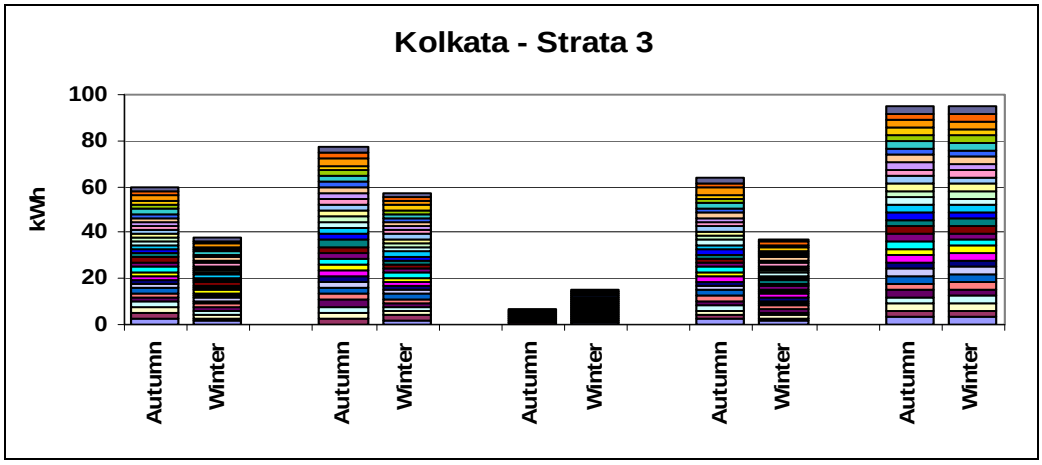
a) Daily energy consumptive figures of Refrigerators:

Strata – 3 : Autumn (Refrigerators)
Strata –3 : Winter (Refrigerators)





b) The comparison of cumulative energy consumptive figures for the two seasons for strata – 3 is depicted in bar chart:



The monthly energy for three house hold for winter seasons is lesser than autumn season. In one of the house hold the autumn energy consumption is lower than winter due house lock. Further the house total consumption is very less than the other house hold. The energy consumption ranges from 15kWh to 94 kWh.

c) The seasonal consumptive figures of air conditioners for Autumn and Winter months are tabulated below:

House ID	Autumn	Winter
	kWh / month	kWh / month
11	19	0
12	0	0
13	86	0
14	0	0
15	31	0

d) Statistical Analysis of Strata – 3 for autumn and winter

Strata –3 : Autumn (Refrigerators & AC)
Strata –3 : Winter (Refrigerators & AC)

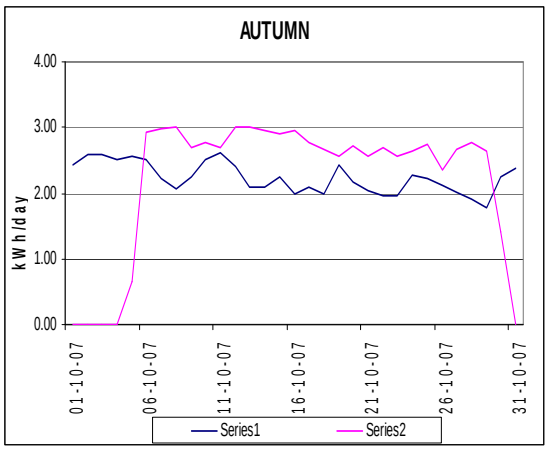
Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	60.34	27.22	292.00
Max	94.68	86.11	432.39
Min	6.78	0.02	222.37
SD	32.93	35.45	87.24
CV	0.55	1.30	0.30

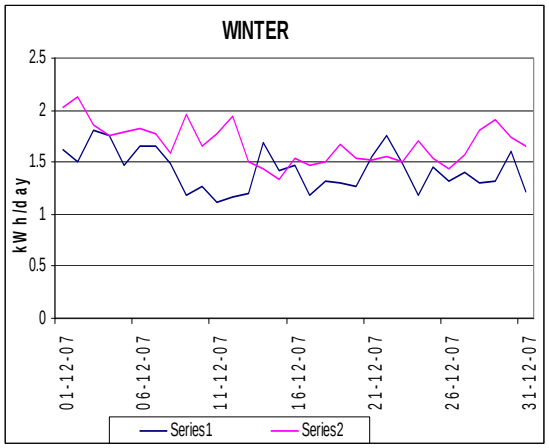
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household _ kWh_ Winter
Mean	48.31	0.00	245.10
Max	94.70	0.00	362.00
Min	15.24	0.00	167.20
SD	29.91	0.00	86.88
CV	0.62	.	0.35

8.3.4 Strata – 4 (Society):

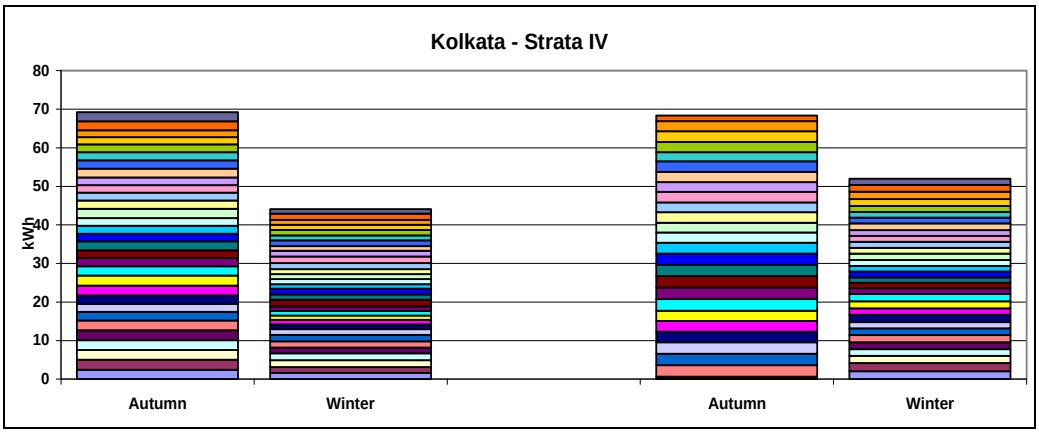
a) Daily energy consumption trend of Refrigerators:

Strata – 4 : Autumn (Refrigerators)
Strata –4 : Winter (Refrigerators)





b) The comparison of cumulative energy for the two seasons for strata – 4 is depicted in bar chart:



The monthly energy for winter seasons is lesser than autumn season. The energy consumption ranges from 44 kWh to 69 kWh.

c) The seasonal energy consumptive figures of air conditioners for Autumn and Winter months are tabulated below:

House ID	Autumn	Winter
	kWh / month	kWh / month
16	60	0
17	6	0

d) Statistical data of Strata – 4 for Autumn and Winter

Strata –4 : Autumn (Refrigerators & AC)
Strata –4 : Winter (Refrigerators & AC)

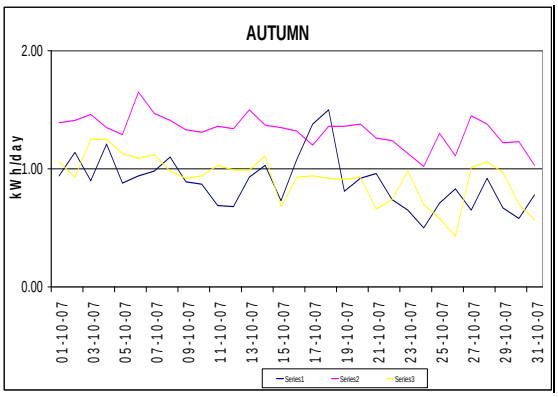
Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	68.79	33.10	302.48
Max	69.22	60.33	397.46
Min	68.36	5.86	207.50
SD	0.61	38.52	134.32
CV	0.01	1.16	0.44

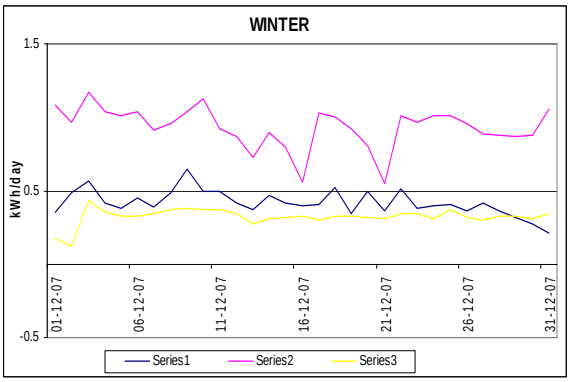
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household _ kWh_ Winter
Mean	48.06	0.00	312.65
Max	52.00	0.00	375.69
Min	44.11	0.00	249.61
SD	5.58	0.00	89.15
CV	0.12	.	0.29

8.3.5 Strata – 5 (Village):

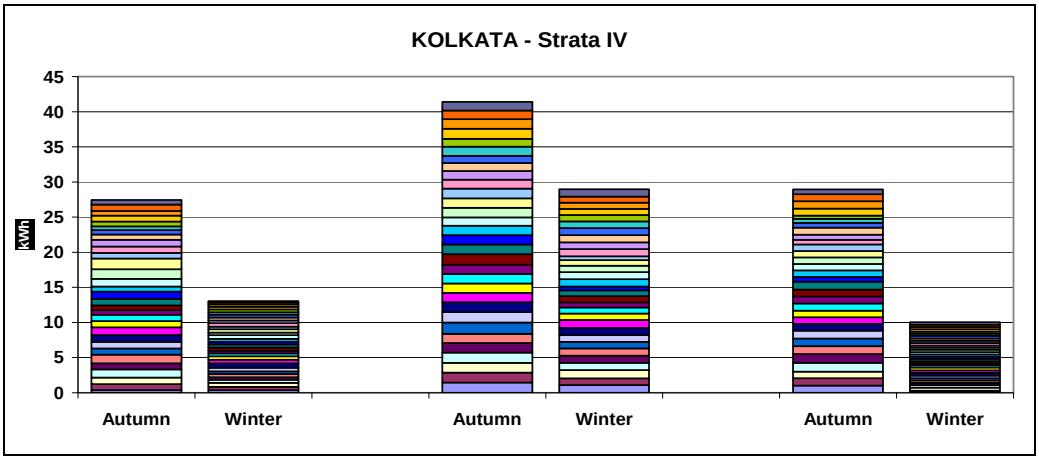
a) Daily energy consumptive profiles of Refrigerators:

Strata – 5 : Autumn (Refrigerators)
Strata –5 : Winter (Refrigerator)





b) The comparison of cumulative energy figures for the two seasons for strata – 5 is depicted in bar chart:



The monthly energy for winter seasons is lesser than autumn season. The energy consumption ranges from 10 kWh to 41 kWh.

c) Air Conditioner is not available for the strata.

d) Statistical data of Strata – 5 for autumn and winter

Strata –5 : Autumn (Refrigerators & AC)
Strata –5 : Winter (Refrigerators & AC)

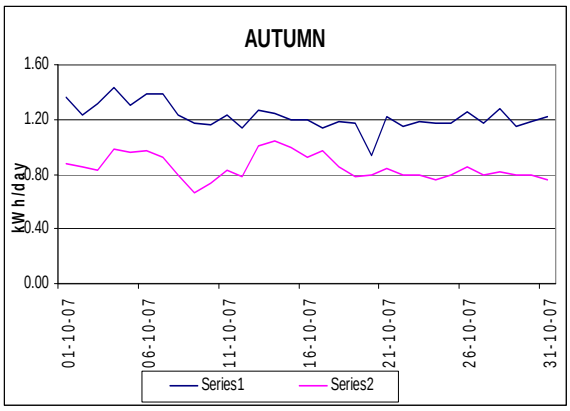
Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	32.60	0.00	163.66
Max	41.41	0.00	216.14
Min	27.45	0.00	120.65
SD	7.67	0.00	48.44
CV	0.24	.	0.30

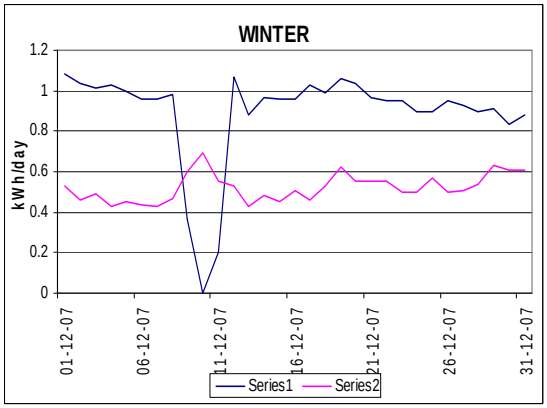
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household _ kWh_ Winter
Mean	17.35	0.00	148.41
Max	28.98	0.00	203.71
Min	10.02	0.00	101.73
SD	10.19	0.00	51.53
CV	0.59	.	0.35

8.3.6 Strata – 6 (Slums)

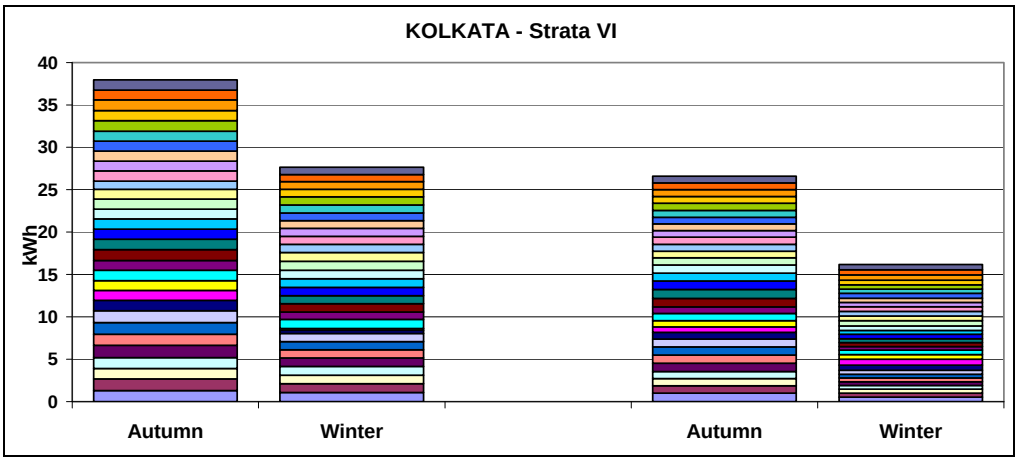
a) Daily energy consumptive profile of Refrigerators:

Strata – 5 : Autumn (Refrigerators)
Strata –5 : Winter (Refrigerator)





b) The comparison of cumulative energy figures for the two seasons for strata – 6 is depicted in bar chart:



The monthly energy for winter seasons is lesser than autumn season. The energy consumption ranges from 16 kWh to 38 kWh.

c) Air Conditioner is not available for the strata.

d) Statistical data of Strata – 6 for autumn and winter:

Strata –6: Autumn (Refrigerators & AC)
Strata- 6 : Winter (Refrigerators & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	32.27	0.00	106.30
Max	37.94	0.00	108.52
Min	26.59	0.00	104.08
SD	8.03	0.00	3.14
CV	0.25	.	0.03

Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household _ kWh_ Winter
Mean	21.92	0.00	95.95
Max	27.66	0.00	98.10
Min	16.17	0.00	93.80
SD	8.12	0.00	3.04
CV	0.37	.	0.03

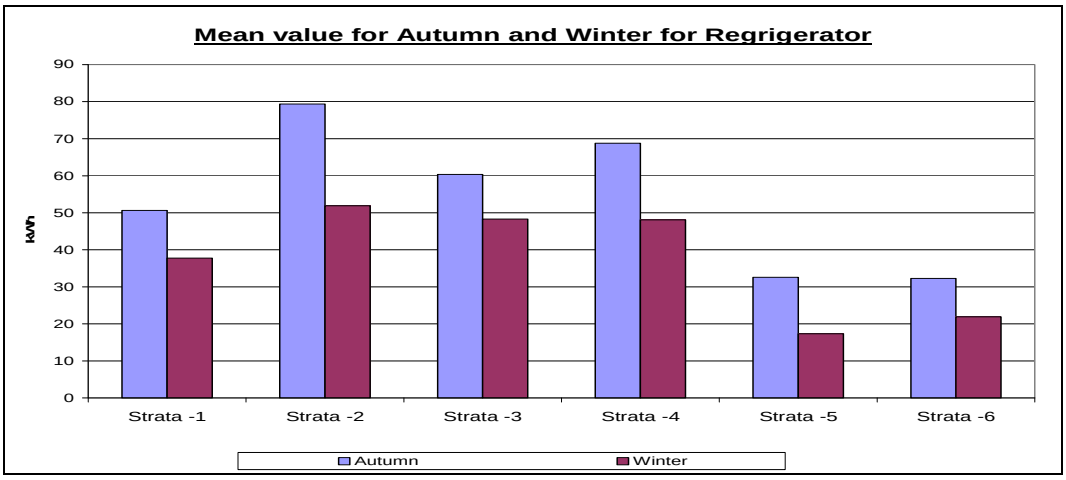
8.3.7 Strata 1 to 6 (total) Statistical data for all Strata for Autumn and Winter

a) **Refrigerators - Energy profile in a nutshell**:

Strata	Autumn			Winter			
	Mean	Max	Min	Mean	Max	Min	
	Urban strata						
1	50.63	73.09	23.03	37.76	51.59	11.81	25.4
2	79.35	92.13	63.1	51.89	58.38	48.57	34.6
3	60.34	94.68	6.78	48.31	94.70	15.24	19.9
4	68.79	69.22	68.36	48.06	52.00	44.11	30.1
	Rural strata						
5	32.60	41.41	27.45	17.35	28.98	10.02	46.8
6	32.27	37.94	26.59	21.92	27.66	16.17	32.1

- It can be observed that mean values for urban strata is higher than the rural strata.

Mean values of autumn and winter is depicted in bar chart. It can be seen that winter month values are lower than autumn values.



b) **Statistical data for all strata together for Kolkata:**

Total: Autumn (Refrigerators & AC)
Total : Winter (Refrigerators & AC)

strata	Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household _ kWh_ Autumn
Total 1 to 6	N	20	20	276.77
	Mean	54.64	42.52	535.68
	Max	94.68	173.43	104.08
	Min	6.78	0.00	138.15
	SD	24.30	54.16	0.50
	CV	0.44	1.27	276.77

Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
N	20	20	236.69
Mean	38.90	0.36	488.85
Max	94.70	7.18	93.80
Min	10.02	0.00	118.07
SD	20.48	1.61	0.50
CV	0.53	4.46	236.69

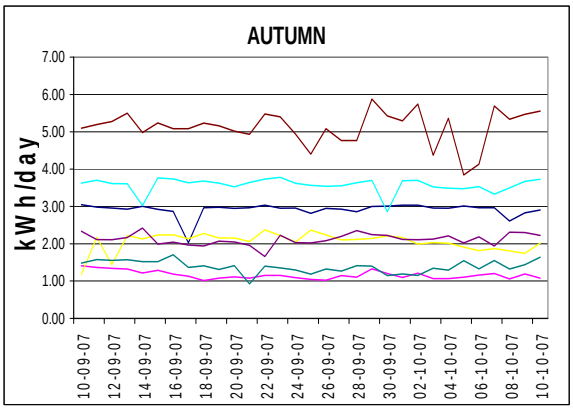
8.4 Bangalore Metro:

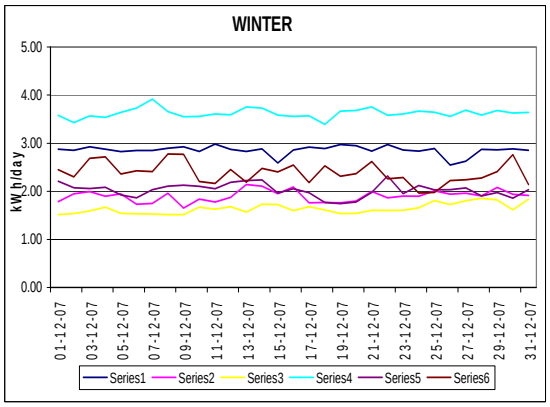
The recorded values of data loggers for Refrigerators and Air Conditioners for 20 houses were down loaded and the hourly values hard copied for autumn and winter have been provided**.** The trends of daily energy consumption values for the two months, Strata - wise are depicted in the graph below:

8.4.1 Strata – 1(Independent House/Bungalow) :

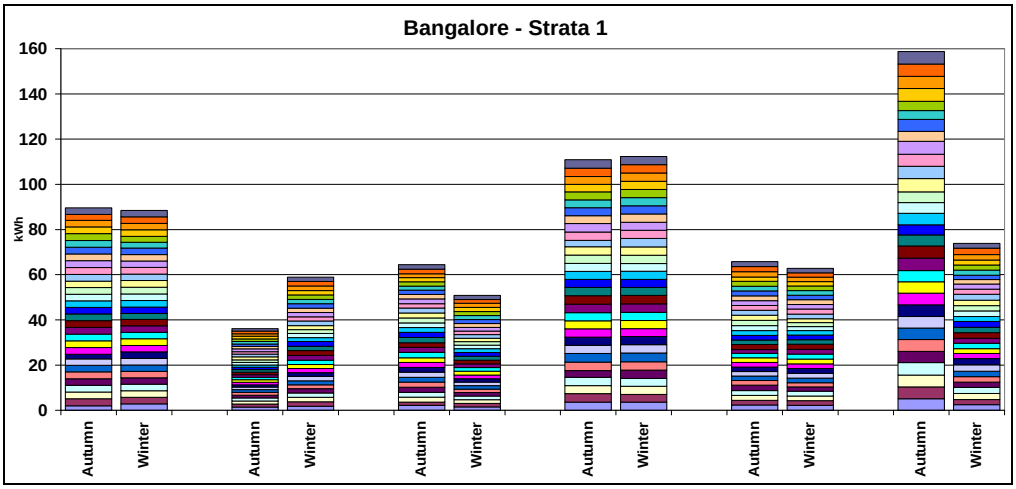
a) Daily energy consumptive profile of Refrigerators:

Strata –1 : Autumn (Refrigerators)
Strata –1 : (Refrigerators)





b) The comparison of cumulative energy figures for the two seasons for strata –1 is depicted in bar chart:



Out of six houses only three houses monthly energy for winter seasons is lesser than autumn season. Rest has almost same and higher energy consumption for winter season. The energy consumption ranges from 43 kWh to 158 kWh.

c) The seasonal energy consumptive figures of air conditioners for autumn and winter months are tabulated below:

House ID	Autumn	Winter
	kWh / month	kWh / month
1	21.9	0.0
2	1.3	0.3
3	13.9	0.0
4	0.1	0.0
5	0.0	1.5
6	0.0	0.0

The consumption is almost nil for both the season.

a) Statistical Analysis of Strata – 1 for Autumn and Winter:

Strata –1: Autumn (Refrigerators & AC)
Strata- 1 : Winter (Refrigerator & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	84.25	6.20	308.68
Max	158.80	21.89	479.06
Min	36.13	0.00	200.18
SD	45.53	9.41	111.66
CV	0.54	1.52	0.36

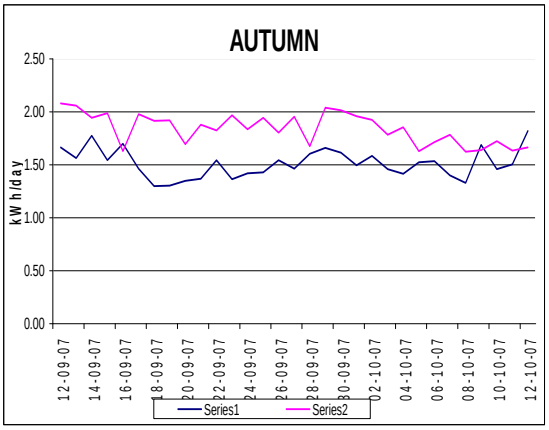
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
Mean	74.52	0.29	313.81
Max	112.30	1.47	442.09
Min	50.83	0.00	207.16
SD	22.64	0.59	85.24
CV	0.30	2.03	0.27

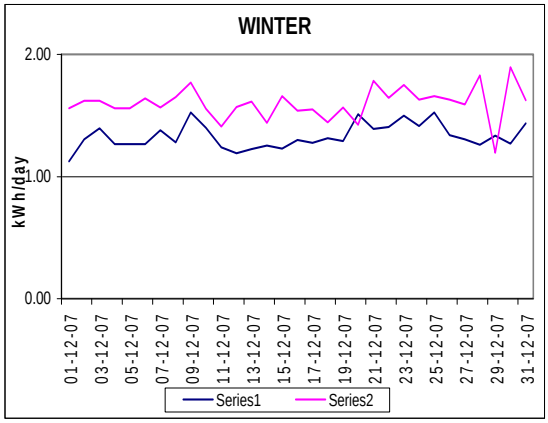
- The standard deviation is on the higher side.

8.4.2 Strata – 2 (Flats):

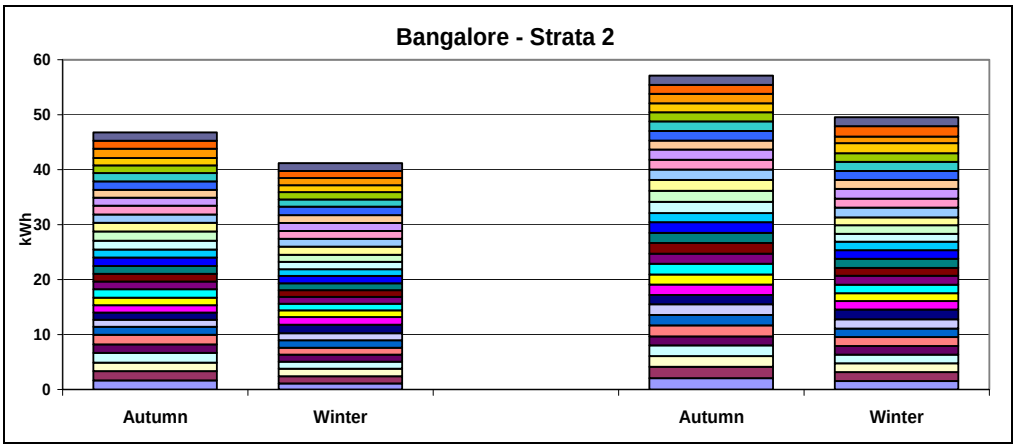
a) Daily energy consumptive profile of Refrigerators during season period:

Strata –2 : Autumn (Refrigerators)
Strata –2 : Winter (Refrigerators)





b) The comparison of cumulative figures for the two seasons for strata –2 is depicted in bar chart:



The monthly energy for winter seasons is lesser than autumn season. The energy consumption ranges from 41 kWh to 50 kWh.

c) The seasonal energy consumptive figures of air conditioners for Autumn and Winter months are tabulated in the following table:

House ID	Autumn	Winter
	kWh / month	kWh / month
1	3.6	0.00
2	7.0	0.00

The usage is almost nil for both the season.

d) Statistical Analysis of Strata – 2 for Autumn and Winter:

Strata –2: Autumn (Refrigerators & AC)
Strata-2 : Winter (Refrigerators & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	51.94	5.27	243.45
Max	57.11	6.97	281.91
Min	46.78	3.56	204.98
SD	7.30	2.41	54.39
CV	0.14	0.46	0.22

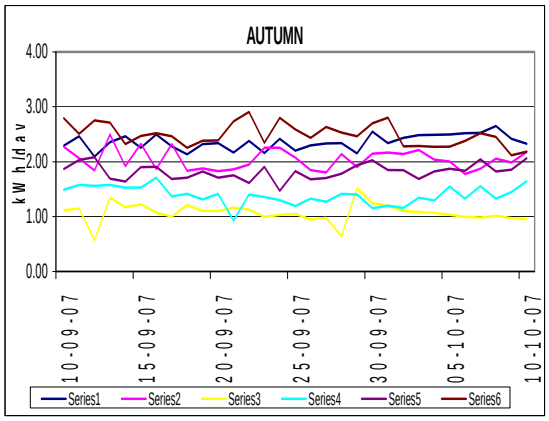
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
Mean	45.39	0.00	227.25
Max	49.56	0.00	271.00
Min	41.22	0.00	183.51
SD	5.90	0.00	61.87
CV	0.13	.	0.27

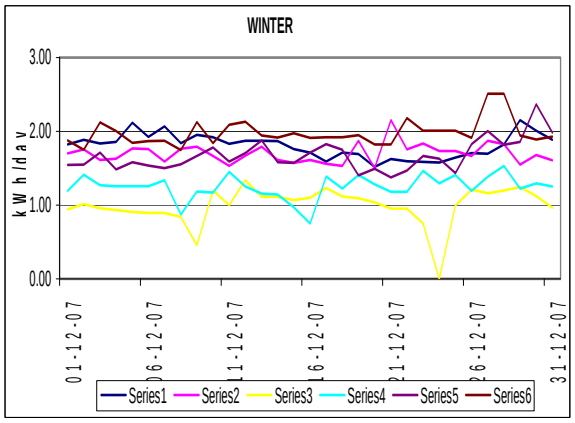
The standard deviation is quite low and min to max values are close to each other.

8.4.3 Strata – 3 (Multi storied buildings):

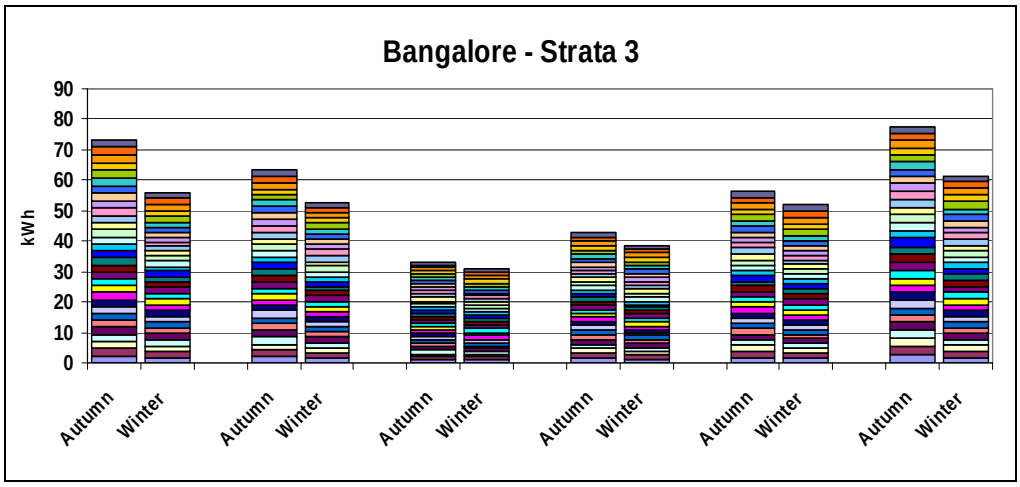
a) Daily energy consumptive profile of Refrigerators during the season periods:

Strata –3 : Autumn (Refrigerators)
Strata –3 : Winter (Refrigerators)





b) The comparison of cumulative energy consumptive figures for the two seasons for strata –3 is depicted in bar chart:



The monthly energy for winter seasons is lesser than autumn season. The energy consumption ranges from 31 kWh to 77 kWh.

c) The cumulative energy consumptive figures of air conditioners for autumn and winter months are tabulated below:

House ID	Autumn	Winter
	kWh / month	kWh / month
1	49.3	0.0
2	12.1	1.4
3	8.4	0.8
4	0.0	0.0
5	0.0	0.0
6	0.0	0.0

The consumption of Air conditioner is almost nil.

d) Statistical Analysis of Strata – 3 for autumn and winter:

Strata –3: Autumn (Refrigerators & AC)
Strata- 3 : Winter (Refrigerators & AC)

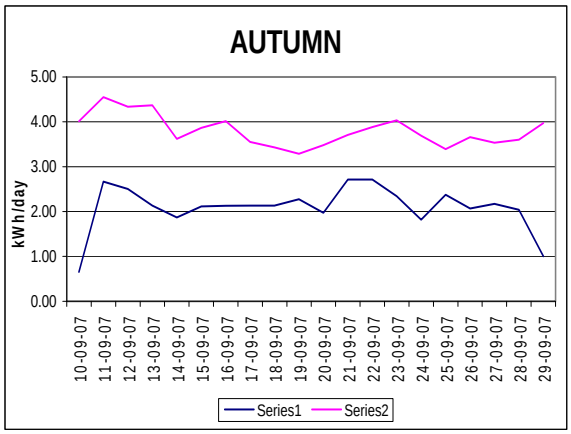
Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	57.78	11.63	314.76
Max	77.67	49.25	446.21
Min	33.15	0.00	220.00
SD	17.25	19.14	89.25
CV	0.30	1.65	0.28

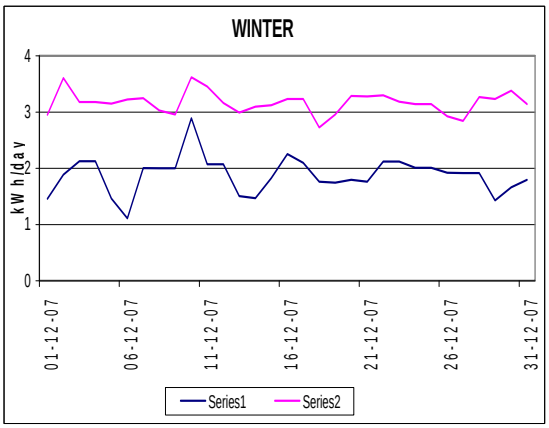
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
Mean	48.52	0.38	288.57
Max	61.33	1.43	432.00
Min	30.77	0.00	204.41
SD	11.49	0.61	94.65
CV	0.24	1.61	0.33

8.4.4 Strata – 4 (Society):

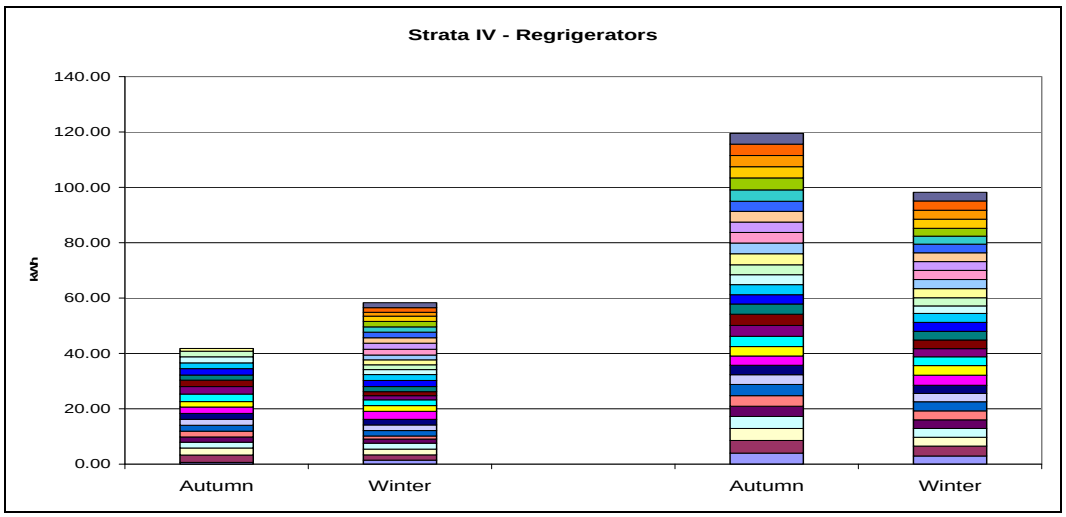
a) Daily energy consumption trend of Refrigerators:

Strata –4 : Autumn (Refrigerators)
Strata –4 : Winter (Refrigerator)





b) The comparison of cumulative energy consumptive figures for the two seasons for strata –4 is depicted in bar chart:



Though the cumulative energy consumption in winter in one of house is indicative higher, but the refrigerator is not used for nearly 11 days as the end

user was out of station. The energy consumption ranges from 58 kWh to 111 kWh.

c) The cumulative consumptive figures of air conditioners for Autumn and Winter months are tabulated below:

House ID	Autumn	Winter
	kWh / month	kWh / month
1	0.0	0.00
2	3.3	0.00

The Air conditioners are not in use.

d) Statistical Analysis of Strata – 4 for autumn and winter:

Strata –4: Autumn (Refrigerators & AC))
Strata-4 : Winter (Refrigerators & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	78.69	1.64	303.50
Max	115.56	3.27	317.69
Min	41.82	0.00	289.30
SD	52.15	2.31	20.07
CV	0.66	1.41	0.07

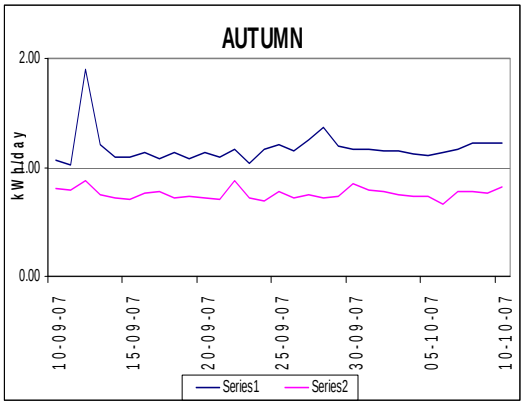
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
Mean	78.30	0.00	271.35
Max	98.25	0.00	288.76
Min	58.34	0.00	253.93
SD	28.22	0.00	24.63
CV	0.36	.	0.09

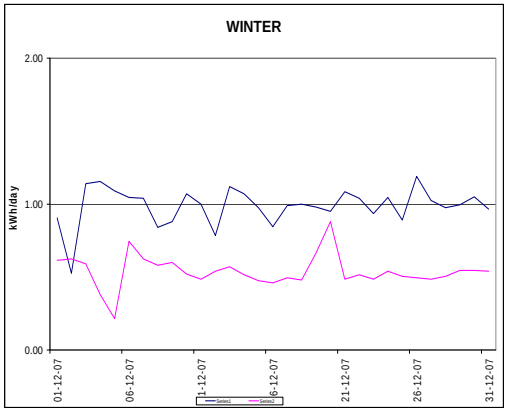
The standard deviation is on the higher side for refrigerator.

8.4.5 Strata – 5 (Village) :

a) Daily energy consumptive trend of Refrigerators:

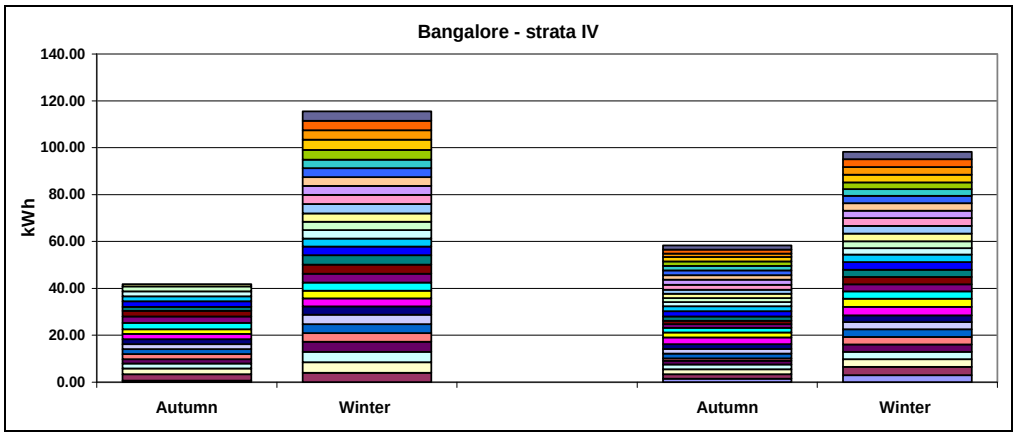
Strata –5 : Autumn (Refrigerators & AC)
Strata –5 : Winter (Refrigerators & AC)





- The energy consumption by the refrigerators is lower for winter.

b) The cumulative comparative figures of energy consumption for the two seasons for strata –5 is depicted in bar chart:



Here the energy consumption is in contrast, where the monthly energy for winter seasons is higher than autumn season. The energy consumption ranges from 42 kWh to 119 kWh.

c) Air Conditioner is not available for the strata.

d) Statistical Analysis of Strata – 5 for autumn and winter:

Strata –5: Autumn (Refrigerators & AC)
Strata-5 : Winter (Refrigerators & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	26.95	0.00	145.61
Max	30.42	0.01	208.22
Min	23.48	0.00	83.00
SD	4.91	0.00	88.54
CV	0.18	0	0.61

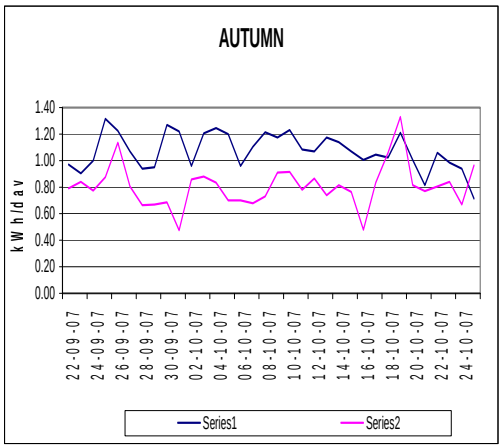
Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
Mean	23.65	0.00	133.72
Max	30.60	0.00	201.44
Min	16.71	0.00	66.00
SD	9.83	0.00	95.77
CV	0.42	0	0.72

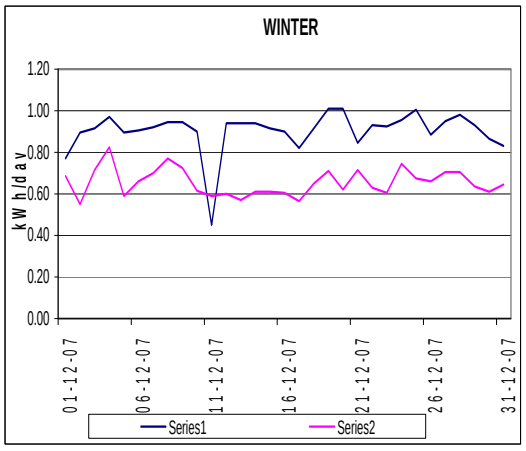
- The standard deviation is low for both the seasons in case of refrigerators.

8.4.6 Strata – 6 (Slums):

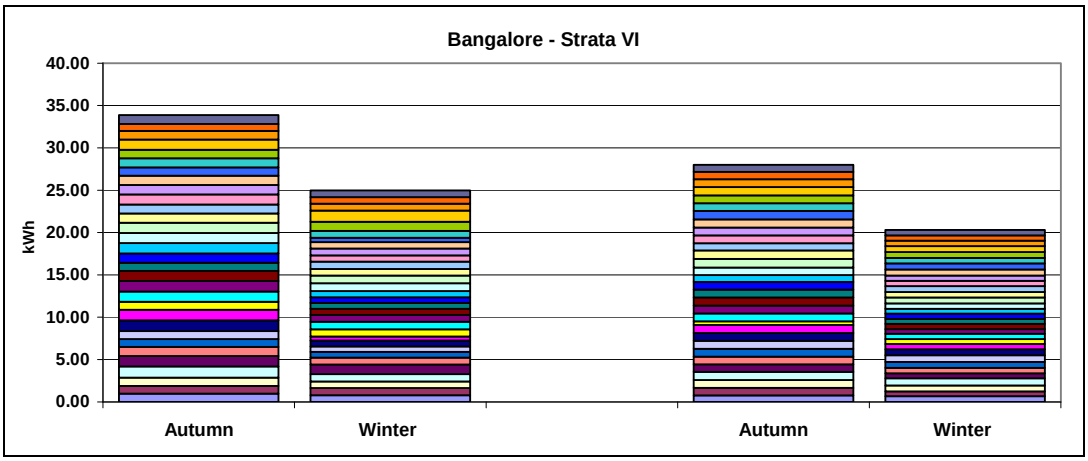
a) Daily energy consumptive profile of Refrigerators:

Strata –6 : Autumn (Refrigerators))
Strata –6 : Winter (Refrigerators)





b) The cumulative comparative figures of energy consumption for the two seasons for strata –6 is depicted in bar chart:



d) Air Conditioner is not available for the strata.

d) Statistical Analysis of Strata – 6for autumn and winter:

Strata –6: Autumn (Refrigerators & AC)
Strata-6 : Winter (Refrigerators & AC)

Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household_ kWh_ Autumn
Mean	29.43	0.00	110.32
Max	33.87	0.00	160.64
Min	24.99	0.00	60.00
SD	6.28	0.00	71.17
CV	0.21	0	0.65

Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
Mean	24.15	0.00	56.00
Max	28.00	0.00	102.00
Min	20.30	0.00	32.53
SD	5.45	0.00	79.00
CV	0.23	0.00	0.41

- The standard deviation is low for both the seasons in case of refrigerators.

8.4.7 Statistical data for all Strata together for Bangalore for Autumn and Winter:

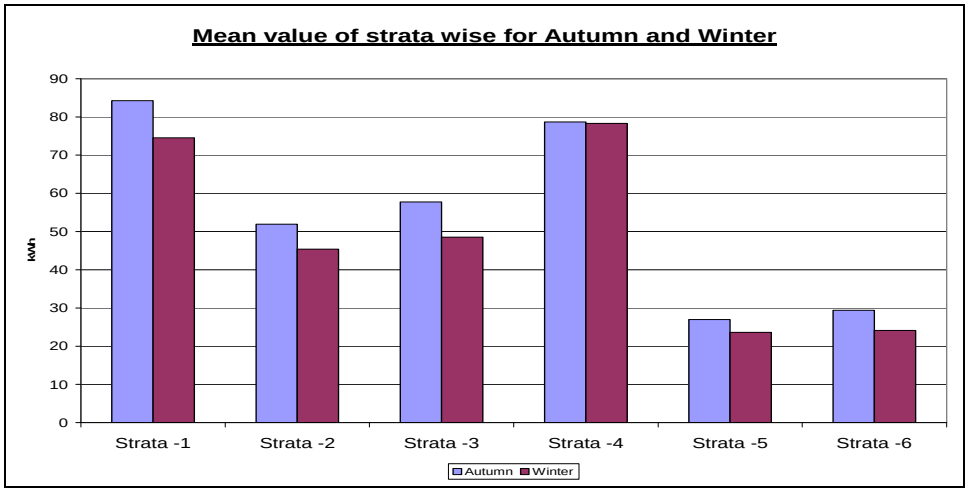
a) Refrigerator - Energy profiles in a nutshell:

Strata	Autumn			Winter			Mean value % variation
	Mean	Max	Min	Mean	Max	Min	
	Urban strata						
1	84.25	158.80	36.13	74.52	112.30	50.83	11.5
2	51.94	57.11	46.78	45.39	49.56	41.22	12.6
3	57.78	77.67	33.15	48.52	61.33	30.77	16.0
4	78.69	115.56	41.82	78.30	98.25	58.34	0.5
	Rural strata						
5	26.95	30.42	23.48	23.65	30.60	16.71	12.2

6	29.43	33.87	24.99	24.15	28.00	20.30	17.9

- It can be observed that mean values for urban strata is higher than the rural strata.

Mean values of autumn and winter is depicted in bar chart. It can be seen that winter month values are lower than autumn values.



b) Statistical data for all strata together for Bangalore

Autumn (Refrigerators & AC)
Winter (Refrigerators & AC)

strata	Statistics	Ref_ kWh_ autumn	AC _ Kwh _ Autumn	Total Household _ kWh_ Autumn
Total 1 to 6	N	20.00	20.00	20.00
	Mean	61.31	6.04	267.32
	Max	158.80	49.25	479.06
	Min	23.48	0.00	60.00
	SD	34.86	11.83	108.79
	CV	0.57	1.96	0.41

Statistics	Ref_ kWh_ winter	AC _ Kwh _ Winter	Total Household_ kWh_ Winter
N	20.00	20.00	20.00
Mean	54.06	0.20	251.84
Max	112.30	1.47	442.09
Min	16.71	0.00	56.00
SD	24.96	0.47	106.76
CV	0.46	2.33	0.42

8.5 An attempt has been made to assess the impact of energy consumption of AC & Refrigerator with respect to total house hold energy and details are as follows:

Metro	Percentage average Energy consumption over house hold energy consumption			
	Autumn		Winter	
	Ref.	AC	Ref.	AC

Delhi	26.2	1.3	23.1	0.0
Mumbai	26.4	19.3	45.0	7.9
Kolkata	22.0	11.8	18.5	0.1
Bangalore	25.3	2.0	25.3	0.1

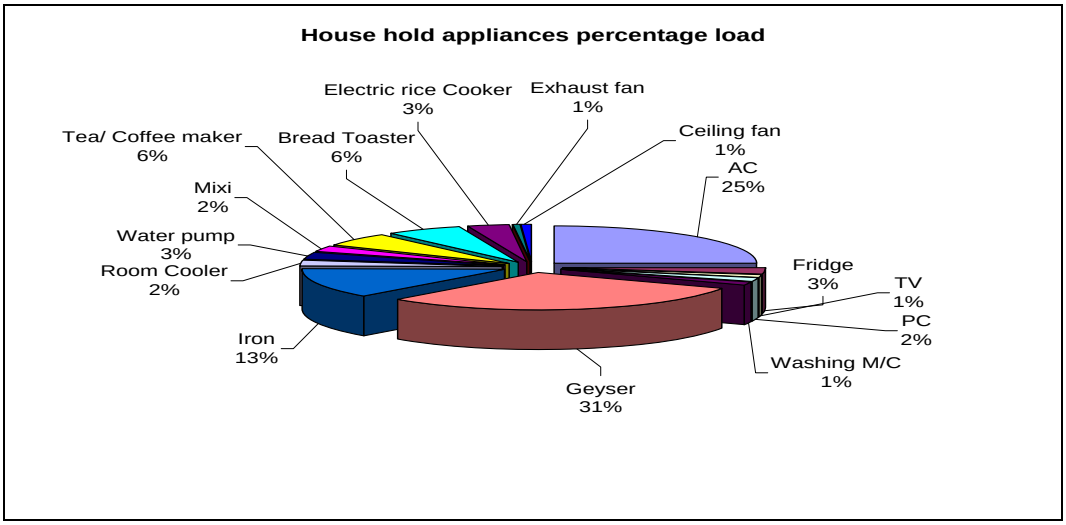
9.0 CATEGORY – 2 MEASUREMENTS:

Under Category – 2 there are 30 houses in each metro to be covered for instantaneous measurements of all the appliances. One time measurement at all the 120 houses at four metro's have been completed. However, there were lots of difficulties faced during repeated measurements, as end users were reluctant to allow survey / measuring teams. However, it was observed that there was no marked change in the load on the equipments of the respondents. The measured values of house hold appliances of four metros are also provided.

a) The type of equipments and range of load are as follows:

Sl. No.	Appliances	Load watt	Remarks
1	AC	590 - 2952	Sleep mode power 10-20 watt
2	Fridge	79 - 375	Sleep mode power 12-30 watt
3	TV	37 - 197	Sleep mode power 8-15 watt
4	PC	66 - 175	Sleep mode power
5	Washing M/C	100	
6	Geyser	1855 - 3500	
7	Iron	395 - 1385	
8	Room Cooler	185	
9	Water pump	220 - 290	
10	Mixer	60 - 276	
11	Tea/ Coffee maker	420 - 470	
12	Bread Toaster	450	
13	Electric rice Cooker	250	
14	DVD	6 - 15	
15	Exhaust fan	40	
16	Ceiling fan	60	
17	Bulb	15, 40, 60	
18	CFL	11, 18	
19	Tube light	50	

b) The variation in load is due to its different capacities. Following is the pie chart indicating a typical percentage loading of various appliance of a house hold:



c) The type of equipments and % of loading on the basis of 'kw' measurements at all houses are as follows. In case of Delhi, where the outside temperature during seasons vary in large & room heaters will be used in winter extensively, requiring of knowing variance in % loading due to this. Hence for Delhi % loading of one in autumn and for winter has been listed.

House Hold Appliances	% loading w.r.t house hold total appliance load				
	DELHI (Autumn)	DELHI (Winter)	MUMBAI	KOLKATA	BANGALO
	Range (watt)	Range (watt)	Range (watt)	Range (watt)	Range (wa
TV	0.4 - 2.8	0.4 - 3.0	0.6 - 13.8	0.5 - 5.2	0.6 -
Geyser	22.8 - 56.2	20.9 - 52.9	26.1 - 53.6	24.9 - 62.6	12.7 -
Fridge	1.2 - 9.4	1.1 - 10.2	1.2 - 32.2	1.1 - 9.3	1.2 -
AC	18.6 - 46.4	17.5 - 44.7	17.6 - 59.0	7.8 - 59.1	9.2 -
PC	0.8 - 5.9	0.8 - 6.2	0.9 - 4.2	1.0 - 8.5	0.7 -
Washing M/C	1.8 - 13.6	1.8 - 14.3	2.0 - 13.3	2.5 - 17.7	1.5 -
Iron	6.7 - 47.2	6.3 - 50.8	5.9 - 64.3	6.7 - 53.7	4.0 -
Room cooler	0.7 - 7.1	0.0 - 0.0	0.0 - 0.0	0.0 - 0.0	0.0 -
Room heater	0.0 - 0.0	5.0 - 32.1	0.0 - 0.0	0.0 - 0.0	0.0 -
Water pump	2.5 - 20.8	2.4 - 19.1	2.7 - 6.1	3.4 - 16.4	2.0 -
Mixi	0.9 - 11.8	0.9 - 12.7	0.9 - 23.9	1.3 - 8.1	0.9 -
Tea/ Coffee maker	3.1 - 4.7	2.9 - 4.4	0.0 - 0.0	6.7 - 6.7	2.5 -
Bread Toaster/oven	7.4 - 15.7	7.1 - 15.6	0.0 - 0.0	6.5 - 24.3	8.3 -
Electric rice Cooker	1.4 - 1.4	1.4 - 1.4	0.0 - 0.0	3.1 - 9.9	1.2 -
Exhaust fan	0.3 - 2.4	0.3 - 2.5	0.5 - 0.7	0.4 - 5.2	0.2 -
CFL's	0.1 - 3.9	0.1 - 4.2	0.3 - 3.9	0.2 - 1.9	0.1 -
Bulbs	0.2 - 12.5	0.2 - 9.1	0.5 - 8.0	0.6 - 9.6	0.3 -
Tube lights	0.6 - 7.8	0.6 - 6.6	2.7 - 11.6	1.5 - 18.6	1.4 -
fans	0.6 - 9.4	0.5 - 8.2	1.8 - 12.0	2.4 - 18.6	1.2 -

It can be seen that Refrigerator load constitutes very low percentage of total load, where as Air Conditioner load constitutes a major load in house hold. However the energy consumption is dependent on the number of hours of usage of the equipments.

10.0 PENETRATION OF ENERGY EFFICIENCY:

In Indian market the star rating (efficient equipment) is prevailing now for refrigerators and for Air conditioners. However, the questionnaire based survey (category – 3), conducted for 1600 number of houses covered star rated equipments in the house hold, it is observed that penetration of star rated product is below 7.5% for refrigerator less than 1.5% for air conditioner. There are no other star rated equipment found in the surveyed house hold.

The numbers of star rated refrigerator available in 1600 houses of four metros are listed below:

Metro	Air conditioner (Nos.)	Refrigerator (Nos.)	% Air Conditioner	% Refrigerator
Delhi	-	29	0	7.25
Mumbai	4	8	1	2
Kolkata	8	11	2	2.75
Bangalore	5	21	1.25	5.25

The survey also covered the issue relating to awareness on star rating /labeling programme for house hold appliances. From the feedback, it is very clear that very few have just heard of such programme, indicating that intensive awareness spreading on the subject is necessity in Indian context. While it is also be mentioned that the buying capacity for house appliances for 'middle class' metro residents has increased considering due to improved earnings and their number is also large. The proposed awareness programme on 'star rating' will have to cover this group largely in a defined time line.

11.0 ANALYSIS :

11.1 Engineering Approach

It is well known hypothesis is that, there is a impact of each appliance of the household on the total household energy consumption. This hypothesis can be tested through engineer approach. The engineering approach is based on sample surveys of variables such as number of appliances, rated power of these appliances and number of hours of usage of these appliances. An engineering estimate of electricity consumption of the end-use will mainly depended on the number of hours of usage of the appliances possessed by the households. As this number is obtained from users, it may not be a correct estimate as far as statistical significance is concerned. It depends on the reliability of a person in recollecting the usage hours. For estimating the impacts of energy consumption of the appliances on total household energy consumption, economists have over the years developed several techniques to value them. The study has been carried out based on multiple regression models. This model evaluates the estimated total households' energy consumption based on the each household's energy consumption of the appliance.

Total energy consumption of the household $_{is}$ (Y_i) = f (X_i, strata),

i = 1, 2,…..n. (1)

s = winter and autumn
The above function can be explained through econometric specification, it's with Population Regression Function (PRF)

$Yi = \alpha + \beta X1 + \gamma X2 + ui$ (2)

Where Y is the dependent variable, X2 and X3 are explanatory variables; u is stochastic disturbance term, and i is the ith observation or household. In (2) α is the intercept term. As usual, it gives the mean or average effect on Y of all the variables excluded from the model, although its mechanical interpretation is the average value of Y when X2 and X3 are set equal to zero. The coefficients β and γ are called the partial regression co-efficient. Based on (3) and (4), Sample Regression Function can be written as

$Yi = e(\alpha) + e(\beta) X1 + e(\gamma) X2 + ui$ (3)

These co-efficient are OLS estimators. ui is the residual term, the sample counterpart of the stochastic disturbance term ui. This estimation has satisfied the properties of the Classical Linear Regression Model (CLRM).

Here we use model for assessing the determinants of total household's energy consumption based on household energy consumption of each appliances. In the model (1) the dependent variable is Total household energy consumption in the winter and autumn sessions. It includes energy consumption of the AC and refrigerator. Basically total energy consumption of households leads to improvement in the productivity of economic activities under taken by people and helps in elevating their socio-economic condition. Whereas the less total energy consumption of total household sluggish the momentum and productivity of economic activities undertaken by people.

The independent variable Xi describes household energy consumption of the each appliance and strata which will describes the household condition etc.

11.2 Stock Approach

The second hypothesis of the study is that, there is an impact of each appliance of the load on the total household energy consumption. This hypothesis can be tested through stock approach. To determine electricity consumption in a household obviously its stock of electrical appliances play a major role. If $X_{ij} * W_{ij}$ would be the total electrical load in watts due to this category of appliances. It followings that $L_i = \Sigma (X_{ij} * W_{ij})$ must be the total electrical load in watts due to this category of appliances. It is reasonable to expect the electrical energy consumption E_i (in KWh) of households is correlated with their loads L_i (in kW).

For estimating the impacts of energy consumption of the appliances on total household energy consumption, economists have over the years developed several techniques to value them. The study has been carried out based on multiple regression models. This model evaluates the estimated total households' energy consumption based on the each household's energy consumption of the appliance.

Total energy consumption of the household$_{is}$ (Y_i) = f (X_i, strata),

i = 1, 2,…..n. (1)

s = winter and autumn

X_i = appliance's load

The above function can be explained through econometric specification, it's with Population Regression Function (PRF)

$$Y_i = \alpha + \beta X_1 + \gamma X_2 + u_i \quad (2)$$

Where Y is the dependent variable, X_2 and X_3 are explanatory variables; u is stochastic disturbance term, and *i* is the *i*th observation or household. In (2) α is the intercept term. As usual, it gives the mean or average effect on Y of all the variables excluded from the model, although its mechanical interpretation is the average value of Y when X_2 and X_3 are set equal to zero. The coefficients β and γ are called the partial regression co-efficient. Based on (3) and (4), Sample Regression Function can be written as

$$Y_i = e(\alpha) + e(\beta) X_1 + e(\gamma) X_2 + u_i \quad (3)$$

These co-efficient are OLS estimators. u_i is the residual term, the sample counterpart of the stochastic disturbance term u_i. This estimation has satisfied the properties of the Classical Linear Regression Model (CLRM).

Here we use model for assessing the determinants of total household's energy consumption based on household energy consumption of each appliances. In the model (1) the dependent variable is Total household energy consumption in the winter and autumn sessions. It includes energy loads of the AC, refrigerator and etc. Basically total energy consumption of households leads to improvement in the productivity of economic activities under taken by people and helps in elevating their socio-economic condition. Whereas the less total energy consumption of total household sluggish the momentum and productivity of economic activities undertaken by people.

The independent variable X_i describes household energy loads of the each appliance and strata which will describes the household condition etc. .

Interpretation for Multiple Regression Equation

The meaning of partial regression coefficient is β measures the change in the mean value of Y, $E(Y \mid X_2, X_3)$, per unit change in X_2, holding X_3 constant. In other words, it gives the slope of $E(Y \mid X_2, X_3)$ with respect to X_2, holding X_3 constant. It gives the direct or the net effect of a unit change in X_2 on the mean value of Y, net of X_3. Likewise, γ measures the change in the mean value of Y per unit change in X_3, holding X_2 constant. That is it gives the direct or net effect of a unit change in X_3 on the mean value of Y, net of X_2.

As is typical of any cross-sectional survey, there is heteroscedasticity in the model, which has been reduced by using log-transformation and weights. We could have considered all the relevant variables for analysis, but due to the problem of multi co-linearity some of the variables had to be dropped from estimation.

11.3 Census Approach

The third hypothesis of the study is that, there is an impact of each appliance of the load on the total household energy consumption. This hypothesis can be tested through census approach.

For estimating the impacts of number of the appliances on total household energy consumption, economists have over the years developed several techniques to value them. The study has been carried out based on multiple regression models. This model evaluates the estimated total households' energy consumption based on the each household's energy consumption of the appliance.

Total energy consumption of the household$_{is}$ (Y_i) = f (X_i, strata),

i = 1, 2,.....n. (1)

s = winter and autumn

X_i = number of appliance in the household

The above function can be explained through econometric specification, it's with Population Regression Function (PRF)

$$Y_i = \alpha + \beta X_1 + \gamma X_2 + u_i \qquad (2)$$

Where Y is the dependent variable, X_2 and X_3 are explanatory variables; u is stochastic disturbance term, and *i* is the *i*th observation or household. In (2) α is the intercept term. As usual, it gives the mean or average effect on Y of all the variables excluded from the model, although its mechanical interpretation is the average value of Y when X_2 and X_3 are set equal to zero. The coefficients β and γ are called the partial regression co-efficients. Based on (3) and (4), Sample Regression Function can be written as

$$Y_i = e(\alpha) + e(\beta) X_1 + e(\gamma) X_2 + u_i \qquad (3)$$

These co-efficients are OLS estimators. u_i is the residual term, the sample counterpart of the stochastic disturbance term u_i. This estimation has satisfied the properties of the Classical Linear Regression Model (CLRM).

Here we use model for assessing the determinants of total household's energy consumption based on number of appliances in the household. In the model (1) the dependent variable is Total household energy consumption in the winter and autumn sessions. It includes energy loads of the AC, refrigerator and etc. Basically total energy consumption of households leads to improvement in the productivity of economic activities under taken by people and helps in elevating their socio-economic condition. Whereas the less total energy consumption of total household sluggish the momentum and productivity of economic activities undertaken by people.

The independent variable X_i describes number of appliance in household and strata which will describes the household condition etc. .

Interpretation for Multiple Regression Equation

The meaning of partial regression coefficient is β measures the change in the mean value of Y, $E(Y \mid X_2, X_3)$, per unit change in X_2, holding X_3 constant. In other words, it gives the slope of $E(Y \mid X_2, X_3)$ with respect to X_2, holding X_3 constant. It gives the direct or the net effect of a unit change in X_2 on the mean value of Y, net of X_3. Likewise, γ measures the change in the mean value of Y per unit change in X_3, holding X_2 constant. That is it gives the direct or net effect of a unit change in X_3 on the mean value of Y, net of X_2.

As is typical of any cross-sectional survey, there is heteroscedasticity in the model, which has been reduced by using log-transformation and weights. We could have considered all the relevant variables for analysis, but due to the problem of multicollinearity some of the variables had to be dropped from estimation.

These approaches are used for category 2 also. In the category 2, the study has collected 30 samples, but there is no meter reading in the survey.

11.4 THE RESULTS

11.4.1 Engineering Approach:

In Engineering Approach the *dependent variable* is total household energy consumption (kWh) and *Independent variable*s considered relevant for analysis is the appliance energy consumption and strata.

The study have been categorized the total household consumption for winter and autumn stages in category 1. Further, the study based on engineering approach, it estimates the expected total household consumption by Delhi, Mumbai, Kolkata and Bangalore metros.

The mean usage of AC and refrigerator varies lot among all metros, especially, Delhi and Bangalore the usage of AC in winter almost nil. Delhi and Bangalore shows similar results, similarly Kolkata and Mumbai.

In sum, the total household consumption increase in the winter seasons compare with autumn, due to the usage of heavy appliance like geyser.

d) Regression results: The statistical analysis of four metros and combination of four metros is depicted in the following table:

Table:1 Statistical analysis:

Details	**All India**		**DELHI**		**MUMBAI**		**KOLKATTA**		**BANGALORE**	
	tot_kwh_hh		tot_kwh_hh		tot_kwh_hh		tot_kwh_hh		tot_kwh_hh	
Dependent Variable	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter
ref_kwh_aut (coefficient)	**1.36**		**1.49**		**1.43**		**1.83**		**0.70**	
	(3.9)*		-1.52		(2.44)*		(2.20)*		-0.95	
ref_kwh_win		**1.59**		**1.44**		**1.47**		**1.14**		**1.43**
		(4.49)*		(-1.43)		(4.26)*		-0.85		-1.47
ac_kwh_aut	**0.91**		**0.74**		**0.79**		**1.55**		**1.62**	
	(6.98)*		-0.48		(5.49)*		(3.70)*		-0.85	
ac_kwh_win		**0.93**		**-87.05**		**0.96**		**16.99**		**-22.68**
		(2.86)*		(-0.52)		(4.68)*		-1.06		(-0.53)
Strata $	-25.65	-30.17	-39.42	-49.20	-25.93	-24.10	-7.98	-49.20	-24.33	-28.73
	(-4.20)*	(-5.09)*	(-2.64)*	(-3.71)	(-2.43)*	(-3.49)	(-0.67)	(-1.42)	(-1.59)	(-1.95)

				*						
Cons	246.19	254.04	267.30	295.96	258.28	251.68	135.31	295.96	285.45	262.24
	(7.25)*	(8.59)*	(2.95)*	(4.71)*	(4.13)*	(6.81)*	-1.86	(2.99)*	(3.50)*	(2.90)*
R-Squared	0.68	0.56	0.60	0.59	0.86	0.87	0.71	0.59	0.34	0.49
Adj R – Squared	0.66	0.54	0.53	0.52	0.83	0.85	0.66	0.52	0.21	0.40

** indicate that 1% significance level*

The coefficient of strata shows negative impact on the total household electricity consumption; it indicates the type of household will have impact on their total household electricity consumption. It is proxy for household's socio-economic condition. In the analysis the indicators have been described based on ranking, when the value of the strata increases; it indicates the household condition shows the poorer condition. So there is a negative impact between household condition and total household electricity consumption.

a) The all India level, during autumn the study estimates the refrigerator consumption coefficient is 1.36, implying that for a 1 unit increase in the consumption (kWh) of refrigerator, the demand for total household energy consumption in autumn on an average increases by about 1.36 unit keeping other independent variable constant, whereas in winter session it increases by about 1.59 units.

The overall observation for all India level is that the total household consumption is higher in winter compare with autumn. The reason for that, there are other appliance which consumes more electricity during winter compare with autumn.

In regression results for autumn and winter, the constant term indicates highly significant at 1% level of significance level, indicating that there is a significant impact on dependent variable (total household electricity consumption) apart from our independent variable i.e. water heater and room heater etc.

The study further analyzed in various metros to capture the household electricity consumption in for two seasons.

b) In Delhi, as per the regression results (Table 1 above) the coefficient of Refrigerator and AC electricity consumption shows positive relationship with the total household consumption, but it is insignificant level in autumn and winter session. It indicates there are other variable has a strong relationship with the dependent variable. Here by 1 unit increase in the consumption of refrigerator and AC in autumn, the total household electricity consumption increase by about 1.49 units and 0.74 units respectively, whereas in winter, it increases by 1.44 units for refrigerators.

c) In Mumbai, by 1 unit increase in the consumption (kWh) of refrigerator and AC in autumn, the total household electricity consumption increase by about 1.43 units and 0.792 units respectively at 1% significant level, whereas in winter, it increases by 1.47 units and 0.96 units respectively at 1% significant level.

d) In Kolkata, by 1 unit increase in the consumption (kWh) of refrigerator and AC in autumn, the total household electricity consumption increase by about 1.83 units

and 1.55 units respectively at 1% significant level, whereas in winter, it shows insignificant result.

e) In Bangalore, the results shows insignificant results for autumn and winter, but the coefficient of refrigerator shows positive impact on the total household electricity consumption in winter and autumn. The coefficient of AC shows positive effect during autumn and negative effect during winter seasons. It indicates the usage of AC during winter reduces the total household electricity consumption keeping other appliance's consumption constant. The similar effect happens for Delhi also.

11.4.2 Stock Approach (Category 1 and 2)

In the Stock approach, the dependent variable is total household energy consumption (kWh) and Independent variables thought to be relevant for analysis includes the load of appliance. In table 2 below gives the description of the variables along with their definition.

The study have been categorized the total household consumption for winter and autumn stages in category 1. After the engineering approach, the study further analyzed based on stock approach, it estimates the expected total household consumption by various metros namely Delhi, Mumbai, Kolkata and Bangalore. In all India, the stock approach, the estimation reveals that, the load of AC and fridge plays a positive significant role on total household consumption during autumn session. In the autumn, the household load due to its appliance stock explains only 59% of the variation. This variation similar to the engineering approach also. Similarly, the winter session, AC and fridge plays a significant level. The reason behind that, the seasonal variations are very high across the study areas, this can varies in each metros.

In Delhi, the load of AC and geyser has positive and significant impact on the total household consumption during autumn, but in the winter it becomes insignificant, but again the coefficient of geyser and water pump have positive significant at 1% significant level, it indicates the level is very high on the total household consumption, similarly the load of fridge has significant impact on the total household electricity consumption in both sessions.

Basically the coefficient of AC's load and fridge plays a significant role on the total household consumption in all metros. In the winter, geyser plays a major role in Delhi and Kolkata, but in Bombay and Bangalore, the coefficient of geyser will not have any significant impact on their total household consumption. Following table is the outcome of regression analysis of stock approach of Cat -1.

Table – 2: Stock approach -Regression results

Dependent Variable	All India		Delhi		Mumbai		Kolkata		Bangalore	
	Total kWh/hh		Total kWh/hh		Total kWh/hh		Total kWh/hh		Total kWh/hh	
	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter
ac_lod	0.02	0.02	0.01		0.31		0.05	0.03	0.03	
	(2.46)*	(2.44)*	(2.62)*		(3.75)*		(4.12)*	(6.14)	(2.16)**	
fridge_lod	0.89	0.64	0.26	0.52	0.05	1.14	0.43		0.44	0.41
	(5.26)*	(4.30)*	(2.08)*	(4.73	(0.07).	(1.86)*	(1.87)*		(2.21)	(1.98)

			*	)*		**	**		*	**
Cons	10.61	33.48	9.25	-39.94	20.28	32.60	-77.47	24.39	67.95	
	(0.26).	(1.04).	(0.41).	(-1.61)	(0.30).	(0.35).	(-1.10)	(1.61).	(1.21).	117.19
Prob>F	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
R-Squared	0.59	0.61	0.98	0.98	0.88	0.63	0.94	0.98	0.80	0.69
Adj R – Squared	0.53	0.55	0.96	0.96	0.81	0.41	0.89	0.97	0.69	0.59

In brackets 't' value
*Note: $ indicate that Dummy Variable (Actual Code), * indicate that 1%, ** 5%, ***10%, ****15%, *****20% significance level*

In the category 2, in all India level, the load of AC plays a major role on the total household electricity consumption during autumn session, but in the winter session it has an insignificant impact on the dependent variable.

Due to insufficient observation, the study fails to estimate the total household electricity consumption for Delhi and Mumbai. In Kolkata and Bangalore the load of AC did not play a major role on the total electricity consumption in the household level.

The overall conclusion, the household load due to its appliance stock explains only 32% and 34% for autumn and winter respectively. This variation relatively less compared to category-I.

Table-3: Category 2 – Stock Approach Ression Results

	All India		**Delhi**	**Bombay**	**Kolkata**		**Bangalore**	
	Total kWh / hh				Total kWh / hh		Total kWh / hh	
Dependent Variable	Autumn	Winter			Autumn	Winter	Autumn	Winter
fridge load	0.19	0.22	**INSUFFICIENT OBSERVATION**		0.66		0.47	0.58
	.(0.79)	.(0.81)			(2.29)*		(2.64)*	(2.97)*
ac load	0.08	0.08					-0.03	
	(2.31)*	(2.08)*					.(-0.81)	
Cons	99.26	47.29			149.35	33.65	263.28	173.45
	.(1.41)	.(0.6)			(3.34)*	-0.36	(4.85)*	(4.42)*
Prob>F	0.01	0.01			0.03	0.10	0.04	0.00
R-Squared	0.33	0.34			0.16	0.40	0.28	0.25
Adj R – Squared	0.26	0.26			0.13	0.26	0.20	0.22

In brackets 't' value

11.4.3 Census Approach (Category 1 & 2)

In Census Approach it is the total household energy consumption (kWh) and Independent variables thought to be relevant for analysis include the number of appliance

The census approach of category -1 shows the results for all India level, the number of AC and refrigerator plays a positive and significant impact on the total household electricity consumption during autumn and winter session. Again it varies metro-wise. The number of geyser plays always significant impact on the total household electricity consumption during winter session in all metros except Bombay. These variables have a significant impact at 1% level on the total household electricity consumption.

Table – 4: Cat -1 Census result – Regression Results

Dependent Variable	All India		Delhi		Mumbai		Kolkata	
	Total kWh / hh		Total kWh / hh		Total kWh / hh		Total kWh / hh	
	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter
no ac	52.99	38.52	45.73		133.00	136.84	77.47	
	(2.79)*	(2.35)*	(5.46)*		.(1.65)	(2.59)*	(3.41)*	
no ref	85.55	73.33					5.81	
	(2.01)**	(2.07)**					.(0.10)	
Cons	36.80	50.76		18.29	239.00	157.31	-18.28	87.47
	.(0.71)	(2.35)**		.(0.63)	(5.13)*	(4.72)*	.(-0.35)	(3.23)*
R-Squared	0.42	0.42	0.99	0.95	0.95	0.77	0.90	0.93
Adj R – Squared	0.37	0.37	0.98	0.90	0.85	0.68	0.81	0.91

In the category 2, in the all India level, the number of AC and geyser plays a positive significant role in the total household electricity consumption in winter and autumn session, but the role of refrigerator does not play a major role on the total household consumption.

The overall conclusion as part of this interim report is that, the AC, geyser and refrigerator will have a major positive impact on the total household electricity consumption. So the urgent need for save energy consumption by introducing the new technology on these appliances.

Table –5: Regression Results – Census Approach – Category 2

Dependent Variable	All India		Delhi		Mumbai		Kolkata		Bangalore	
	Total kWh / hh		Total kWh / hh		Total kWh / hh		Total kWh / hh		Total kWh / hh	
	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter
ac	42.83	24.73	89.78		40.36		73.67	53.79	32.75	
	(3.34)*	(1.91)**	(2.12)*		(2.1)**		(6.52)*	(3.26)*	(1.80)**	

	-1.75	7.41							41.19	60.38
fridge	.(-0.05)	.(0.23)							.(1.53)	(1.95)**
	-13.18	-19.34			-37.70					
tv	.(-0.87)	.(-1.26)			.(-1.25)					
	29.23	43.26		72.39		74.33				
geyser	(2.86)*	(4.2)*		(1.79)**		(2.79)*				
	119.20	(3.06)*	10.22	192.37	137.85	112.17	38.31	28.00	85.02	.(1.29)
Cons	.(3.11)*		.(0.41)	(4.33)*	-4.25	-5.19	.(1.66)	.(0.84)	.(1.51)	
R-Squared	0.57	0.57	0.48	0.32	0.84	0.65	0.85	0.74	0.79	0.56
Adj R – Squared	0.51	0.51	0.38	0.25	0.79	0.61	0.80	0.64	0.70	0.47

*Note: $ indicate that Dummy Variable (Actual Code), * indicate that 1%, ** 5%, ***10%, ****15%, *****20% significance level*
In brackets 't' value

The analysis and graph of all three approaches is listed in **Appendix – 11.1.**

12.0 ENERGY PROJECTIONS FOR BALANCE TWO SEASONS:

As the consumption is negligible by Air conditioner for the two seasons at all the four metros, projection of energy consumption for the balance two seasons is very difficult. The projection for Refrigerators for balance two seasons namely 'Spring' and 'Summer' has been done based on the energy values at sampled houses for the measured two seasons and considering factors due to variations in temperature & humidity during these seasons.

Following table gives average energy per house for each metro for four seasons.

Table 6 : Energy projection for balance two seasons:

Metro	Average Energy per house				REMARKS
	As per the study		As per projection		
	Autumn	Winter	Spring	Summer	
Delhi	56.84	34.90	43.62	71.05	i. 25% on winter value for spring season ii. 25% on Autumn value for summer season
Mumbai	76.10	70.07	77.07	83.71	i. 10% on winter value for spring season ii. 10% on Autumn value for summer season
Kolkata	54.64	38.90	48.62	68.30	i. 25% on winter value for spring season ii. 25% on Autumn value for summer season
Bangalore	62.21	54.06	59.47	68.43	i. 10% on winter value for spring season ii. 10% on Autumn value for summer season

Based on the above average energy values at each house, following table indicates the project able energy consumptive figures for refrigerator energy consumption at four metros.

Metro	House Hold (nos.)	Autumn month	Winter month	Spring month	Summer month
Units	Lakh	MU	MU	MU	MU
Delhi	23.846	135.53	83.22	104.03	169.29
Mumbai	17.743	135.03	124.32	136.75	148.53
Kolkata	9.197	50.25	35.78	44.72	62.81
Bangalore	14.183	88.23	76.67	84.35	97.05

13.0 CONCLUSION

The following paragraphs describes the results of a survey of electricity consumption of two major appliances namely –

- Refrigerator
- Room Air conditioners

at selected 1800 number of households falling under six strata's and four metros of Delhi, Mumbai, Kolkata and Bangalore. The survey of 80 houses involving either intensive data logging of energy for first two seasons of Autumn & Winter and 120 houses involving measuring of appliances in kW loading has revealed the information on:

- The pattern of consumption of electricity especially for refrigerator & Room air conditioners.
- The stock of appliances used by the household.
- The difference in the consumptive pattern of electricity at refrigerator at urban and rural house setting.
- Further, the dialoguing with 1600 houses has also given ideas on –

- Number of persons residing at house
- Type of appliances used
- Energy consumptive figures of household.
- Hours of usage of each appliances
- The degree of penetration of energy efficient appliances / devices

13.1 The following impressions that could be derived from the first two season's study of Autumn & Winter, though a detailed analysis is possible only after two more seasons study including that of summer month when room air conditioners would be used extensively:

- The mean usage of AC and Refrigerator varies among all metros, especially, Delhi and Bangalore the usage of AC in winter is almost nil (ref. Appendix-11.1).
- In Bangalore, the results shows insignificant results for autumn and winter, but the coefficient of refrigerator shows positive impact on the total household electricity consumption in winter and autumn.
- In all India, the stock approach, the estimation reveals that, the load of AC and fridge plays a positive significant role on total household consumption during autumn session. In the autumn, the household load due to its appliance stock explains only 59% of the variation.
- In Delhi, the load of AC and geyser has positive and significant impact on the total household consumption during autumn, but in the winter it becomes insignificant.
- Basically the coefficient of AC's load and fridge plays a significant role on the total household consumption in all metros. In the winter, geyser plays a major role in Delhi and Kolkata, but in Bombay and Bangalore, the coefficient of geyser will not have any significant impact on their total household consumption.
- In the category 2, in all India level, the load of AC plays a major role on the total household electricity consumption during autumn session, but in the winter session it has an insignificant impact.
- The household load due to its appliance stock explains only 32% and 34% for autumn and winter respectively.

- The census approach of category -1 shows the results for all India level, the number of AC and refrigerator plays a positive and significant impact on the total household electricity consumption during autumn and winter session.
- As part of this interim report is that, the AC, geyser and refrigerator will have a major positive impact on the total household electricity consumption. So the urgent need for save energy consumption by introducing the new technology on these appliances.

13.2 In the absence of any 'base line' energy figures for at least one season for room air conditioner, any attempt made to forecast of likely increased consumptive pattern would be a guess work and will not be reliable. In view of this, more thrust in analysis has been made with respect to 'energy usage' issues for another major appliance of household i.e., Refrigerator and energy consumptive pattern have reduced from Autumn to Winter in majority of cases selected as sampled households.

The following table indicates the % of the electricity used by 'Refrigerator' with respect to the house hold energy use during the completed two seasons are as follows:

Metro	**Strata**	**Refrigerator energy as (%) of total household energy**	
		Autum	**Winter**
Delhi	1	23.41	17.62
	2	21.03	12.22
	3	24.51	16.80
	4	28.06	34.06
	5	43.29	41.27
	6	27.56	37.82
	Total	**27.98**	**26.63**
Mumbai	1	24.46	32.27
	2	22.09	43.94
	3	20.65	49.68
	4	29.23	38.36
	5	36.70	33.02
	6	27.56	57.63
	Total	**26.78**	**42.49**
Kolkatta	1	19.73	22.70
	2	22.64	16.02
	3	31.08	19.11
	4	31.12	16.29
	5	39.19	11.13
	6	42.87	22.99
	Total	**31.11**	**18.04**
Bangalore	1	31.93	32.51
	2	22.23	21.11
	3	19.02	17.83
	4	25.41	28.50
	5	21.45	20.25
	6	31.36	31.85
	Total	**27.87**	**28.23**

13.3 The study estimates the expected household's electricity consumption for various metros based on primary household survey. Further it reveals the pattern of the household electricity consumption in winter and autumn session by metro-wise i.e Delhi, Mumbai, Kolkata and Bangalore. It adopts few approaches to estimate the household electricity consumption namely engineering approach, census approach and stock approach. These methodology shows the elasticities based on the effect of unit/percentage increase of appliance penetration on the electricity consumption in winter and autumn. Based on the results, the policy makers can make the decisions on efficiency improvements in certain end-use devices so that increases in requirement for the domestic sector.

In the engineering approach, the study adopts this approach only for category 1, the reason behind that, the study has taken the meter reading only for category I. This approach reveals the impact of actual values (obtained through meter readings recorded by the survey team) on the total household electricity consumption. Its shows the refrigerator and AC's consumption of electricity will have more impact on the total household consumption in the autumn and winter by all India level. The household's electricity consumption due to its appliance meter reading explains only 68% of the variation. The large standard errors indicate that there are huge differences between the estimated and actual values. Hence the engineering approach has limitations in estimating the actual consumption of appliances primarily because it depends largely upon recall of the hours of usage. In the stock approach, the results indicates the similar results compare with engineering approach, but the R^2 of the model i.e stock approach is lesser then engineering approach. In the census approach, shows very low compare with engineering approach, stock approach. However, the engineering approach's R^2 is high compared to the stock and census approach. So the overall conclusion for category 1 indicates that the engineering approach is much better then all other approaches. It means the estimated household consumption and actual household electricity consumption are almost similar by the engineering approach, but this case not applicable for other approach like census and stock approach, the standard error for other approaches are very high compare with engineering approach.

In category II, the study adopted only stock and census approach, the household electricity consumption due to its number of appliances stock explains only 57% of the variation. Even though this is low, it is much better when compared to the stock approach (i.e R^2 = 27%) and the standard error is lower than that in the stock approach. So in the category II, the study suggested that, census approach is much better then stock approach. Based on the R^2 condition, In Delhi, stock approach is the better than other approach like engineering and census approach for category I. Similarly for Category II, census approach is better than other approaches. In stock approach, for Delhi and Bombay shows insufficient variable in the estimation. In Bombay, though the census approach shows very high R^2, but the variation among 'adjusted $R^{2'}$ and R^2 is very high compared to stock and engineering approach. In the case of engineering approach the different between R^2 and 'adjusted $R^{2'}$ will be much lesser than other approaches. The study suggested that, engineering approach is better than other approaches for Bombay for category I. Similarly for category II, only census approach can be solution for the analysis. In category I, for Kolkata, the Stock approach is better than all other approach based on R^2 and for Bangalore, census approach is better than all other approach. Similarly for category II, for

Kolkata and Bangalore, census approach is better than other approach. Limitation in the study, there are some indicators shows insignificant impact on their household electricity consumption due to lack of observation in the study.

Based on the 'Engineering' approach following table lists the estimation of increase in the electricity consumption of the house hold energy consumption by increase in 1 unit of Refrigerator and Air Conditioner:

Details	Season	Increase in house hold energy by increase in 1 kWh of Refrigerator	Increase in house hold energy by increase in 1 kWh of Air Conditioner
ALL INDIA	Autumn	1.36	0.91
	Winter	1.59	0.93
DELHI	Autumn	1.49	0.74
	Winter	1.44	-
MUMBAI	Autumn	1.43	0.79
	Winter	1.47	0.96
KOLKATTA	Autumn	1.83	1.55
	Winter	1.14	16.99
BANGALORE	Autumn	0.7	1.62
	Winter	1.43	-

*the value of Delhi and Bangalore in the case of AC is absurd.

The quick review of survey reports of category-3 of residents at 400 houses and also 50 houses of category 1 & 2 of houses selected for logging / measurement totaling 1800 numbers at 4 metros indicates that 'star' rated equipments are very few (see table under para10.0 above) in the present sampled houses, thereby indicator of a tremendous opportunity of possible market penetration for such energy efficient or 'star rated' house appliances, especially for Refrigerator and room AC.

Policy makers can take further corrective actions by promoting efficiency improvements in at least 4 types of end-user devices, which consume 75% of the household energy, so that increases in the penetration of such devices would contain the overall energy requirements for the domestic sector from the present level.

More focused analysis would be made once all the four season data's are available, especially for room 'air-conditioners' Also a monthly consumptive energy figures for TV would be analysed for which additional 30 houses (15 houses at two metros of New Delhi and Bangalore) are selected now for sampling & energy profile recordings are 'ON'.