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Annexures

Annex 1: Data used in constructing Variables used in Models

Variables	Description	Values
YEARMADE	Gives ranges for when the home was built	<1940; 1940 49; 50 59; 60 69; 70 79; 80 84; 85 89; 90 94; 95 99; 2000 02; 2003; 2004; >2005
HHINCOME	Gives household income ranges from all sources of income of all members of the households	< 2,500, 2,500 -15,000 15000-19,999 20000-49999 50000-100000 >10000
ELWATER	Indicates whether or not a household uses electricity for heating water	Yes or No
ELFOOD	Indicates whether or not a household uses electricity for cooking	Yes or No
ELCOOL	Indicates whether or not a household uses electricity for air conditioning	Yes or No
HD65	Number of heating degree days	Values range from 0 to 11,465
CD65	Number of cooling degree days	Values range from 0 to 5,059
TOTSQFT	Total square footage of the home	Values range from 180 to 9,504
NHSLDMEM	Number that live in the household	Values range from 1 through 15
DOLLAREL	Estimated cost of electricity	Values range from 56 to 6.670
KWH	Number of Kilowatt hours	Values range from 48 to 72,175

Table 10: Variables used to construct the model

Annex 2: Data sample

HH Survey

user_id	LHEC	Lkrel/Kwh	Lowmidin	Midincom	Highincon	ELCOOL	lsqftcool	HHMem	ELFOOD	ELWATER
1	9.507403	0.126235	1	0	0	1	7.595387	2	1	0
2	9.47662	0.133936	0	1	0	1	7.185387	4	0	0
3	9.876322	0.078401	1	0	0	1	8.03106	2	1	0
4	10.26239	0.067016	0	0	0	0	0	8	1	1
5	10.26319	0.064764	0	0	1	1	7.685244	5	1	1
6	9.488881	0.13026	0	1	0	0	0	8	1	0
7	8.881003	0.121768	0	0	1	0	0	2	1	1
8	9.897369	0.066304	0	1	0	0	0	4	1	1
9	9.938758	0.102182	0	0	1	1	8.525161	4	1	0
10	8.947416	0.129813	0	0	1	1	7.843456	1	1	1
11	9.342684	0.07166	1	0	0	1	7.452982	3	1	1
12	9.448254	0.124389	0	1	0	1	8.411833	5	0	0
13	8.769973	0.1064	0	0	0	1	6.723832	1	1	1
14	10.23602	0.10337	0	1	0	1	7.738052	3	1	1
15	8.912473	0.097252	0	0	1	0	0	5	1	1
16	10.08197	0.077464	0	1	0	1	7.35628	2	1	1
17	8.37263	0.155535	1	0	0	0	0	1	0	0

Table 11: Sample data of household survey

Meter Readings

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Date	Time	Voltage	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15
2	16/12/2012	17:24:00	234.84		0	1	17	1	0	17	0	0	0	0	0	0	0	0
3	16/12/2012	17:25:00	233.63		0	1	16	2	0	18	0	0	0	0	0	0	0	0
4	16/12/2012	17:26:00	233.29		0	2	17	1	0	17	0	0	0	0	0	0	0	0
5	16/12/2012	17:27:00	233.74		0	1	17	1	0	17	0	0	0	0	0	0	0	0
6	16/12/2012	17:28:00	235.68		0	1	17	1	0	18	0	0	0	0	0	0	0	0
7	16/12/2012	17:29:00	235.02		0	2	17	1	0	17	0	0	0	0	0	0	0	0
8	16/12/2012	17:30:00	235.09		0	1	17	2	0	17	0	0	0	0	0	0	0	0
9	16/12/2012	17:31:00	235.22		0	1	17	1	0	18	0	0	0	0	0	0	0	0
10	16/12/2012	17:32:00	233.99		0	1	17	1	0	17	0	0	0	0	0	0	0	0
11	16/12/2012	17:33:00	233.86		0	2	16	1	0	17	0	0	0	0	0	0	0	0
12	16/12/2012	17:34:00	232.86		0	1	17	35	0	18	0	0	0	0	0	0	0	0
13	16/12/2012	17:35:00	232.78		0	1	17	38	0	17	0	0	0	0	0	0	0	0
14	16/12/2012	17:36:00	232.99		0	1	16	37	0	17	0	0	0	0	0	0	0	0
15	16/12/2012	17:37:00	232.91		0	2	17	38	0	17	0	0	0	0	0	0	0	0
16	16/12/2012	17:38:00	235.24		0	1	17	37	0	17	0	0	0	0	0	0	0	0
17	16/12/2012	17:39:00	237.14		0	0	17	36	0	17	0	0	0	0	0	0	0	0
18	16/12/2012	17:40:00	236.73		0	0	17	37	0	16	0	0	0	0	0	0	0	0
19	16/12/2012	17:41:00	237.06		0	0	17	37	0	17	0	0	0	0	0	0	0	0
20	16/12/2012	17:42:00	237.13		0	0	18	37	0	17	0	0	0	0	0	0	0	0
21	16/12/2012	17:43:00	235.84		0	0	17	36	0	17	0	0	0	0	0	0	0	0
22	16/12/2012	17:44:00	232.69		0	0	16	37	0	16	0	0	0	0	0	0	0	0
23	16/12/2012	17:45:00	230.98		0	0	17	36	0	17	0	0	0	0	0	0	0	0

Table 12: Sample meter readings

Annex 3: Data analysis results

```
. regress LHEC LkrelKwh Lowmidincome Midincome Highincome ELCOOL lsqftcool HHMem ELFOOD ELWATER
```

Source	SS	df	MS
Model	1108.28402	9	123.142669
Residual	1038.98574	4372	.237645411
Total	2147.26976	4381	.490132335

Number of obs	= 4382
F(9, 4372)	= 518.18
Prob > F	= 0.0000
R-squared	= 0.5161
Adj R-squared	= 0.5151
Root MSE	= .48749

LHEC	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
LkrelKwh	-4.023989	.1611407	-24.97	0.000	-4.339906	-3.708072
Lowmidincome	.0834764	.0200018	4.17	0.000	.0442626	.1226901
Midincome	.1888893	.0216646	8.72	0.000	.1464158	.2313628
Highincome	.2614967	.0245255	10.66	0.000	.2134143	.3095791
ELCOOL	-1.435686	.1228518	-11.69	0.000	-1.676537	-1.194834
lsqftcool	.2403184	.0160395	14.98	0.000	.2088728	.2717639
HHMem	.1315296	.0050774	25.90	0.000	.1215753	.1414839
ELFOOD	.1103993	.0168293	6.56	0.000	.0773954	.1433833
ELWATER	.4411667	.0169611	26.01	0.000	.4079144	.474419
_cons	8.613538	.0293135	293.84	0.000	8.556069	8.671008

Table 13: STATA output table for 9 variables

```
. regress LHEC LkrelKwh Highincome lsqftcool HHMem
```

Source	SS	df	MS
Model	835.376673	4	208.844168
Residual	1311.89309	4377	.29972426
Total	2147.26976	4381	.490132335

Number of obs	= 4382
F(4, 4377)	= 696.79
Prob > F	= 0.0000
R-squared	= 0.3890
Adj R-squared	= 0.3885
Root MSE	= .54747

LHEC	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
LkrelKwh	-4.839555	.1778929	-27.20	0.000	-5.188315	-4.490795
Highincome	.1854326	.0215625	8.60	0.000	.1431592	.2277061
lsqftcool	.063617	.0022234	28.61	0.000	.0592581	.067976
HHMem	.1319003	.0056012	23.55	0.000	.120919	.1428815
_cons	8.978137	.0279444	321.29	0.000	8.923352	9.032922

Table 14: STATA output table for 4 variables

Model	Constant (log)	Value of Constant
Statistical model with 9 variables	8.61	0.93
Statistical model with 4 variables	8.97	0.95
System Statistical model with 4 variables	10.9099	1.03

Value variance in two four variable models (statistical package Vs system inbuilt)

$$variance = \frac{(1.03 - 0.95)}{0.95}\% = 8.86\%$$

Annex 4: Interface

Login Interface

The system is not designed in a way for public use. It's specifically designed for the use of CEB officials as well as CEB customers. So the key administrative privileges will be authorised by the CEB. Anyone who wishes to use the system has to obtain the credentials from the authorities.

Figure 11: Login Screen

Household user home page

This page is showing the current electricity consumption in one second intervals. It is also able to show the household historical electricity consumption. Based on the current usage, customers would be able to calculate the cost for the total usage of the current month. It also gives an indication to the user whether he is using the electricity within the acceptable range or not.

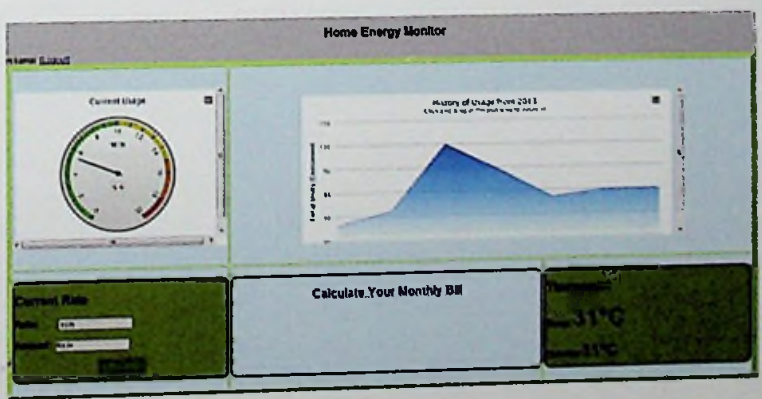

Figure 12: Individual home screen

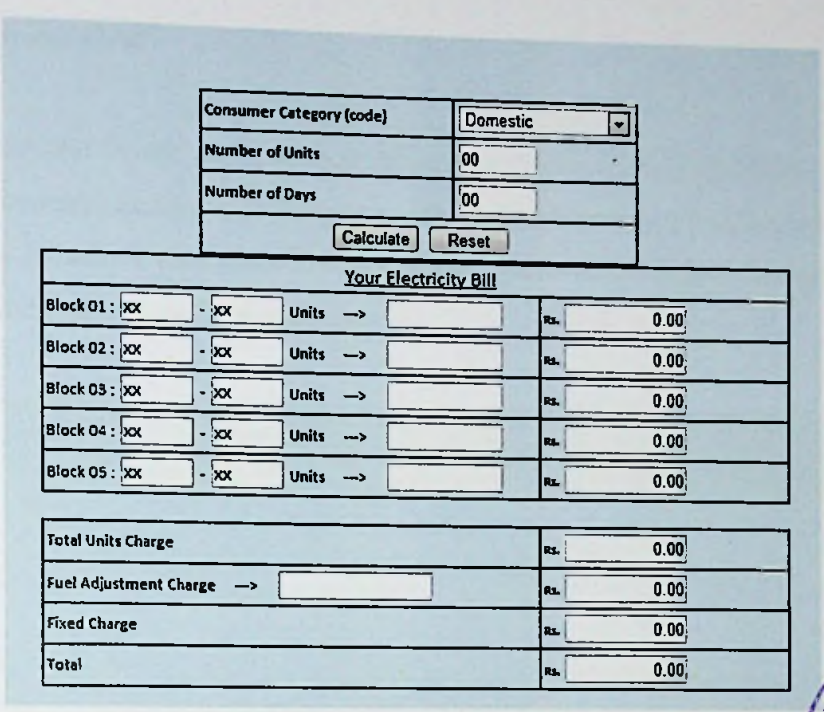

Figure 13: Bill calculator

Administrator home screen

Administrator is the person who could manage consumers. Once consumer details are entered to the system they will assign a unique username and password to check their present consumption. When the consumer is registered he/she should provide the list of electrical equipment that they used in the household. This should be verified by the meter reader and this should be updated atleast twice a year. The house location is verified by the meter reader with the spatial references.

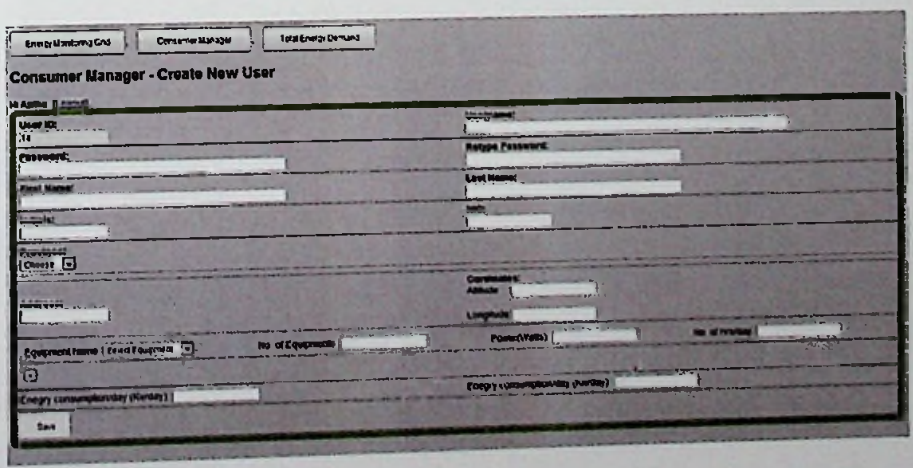

Figure 14: Consumer manager

Energy Monitor Grid

The Administrator is also able to check the individual energy usage in customers in any part of the country. Energy monitor grid is able to narrow down the customers' database into Grama Niladhari divisions. In a particular GN division it lists out all the users registered and their present and past usages.

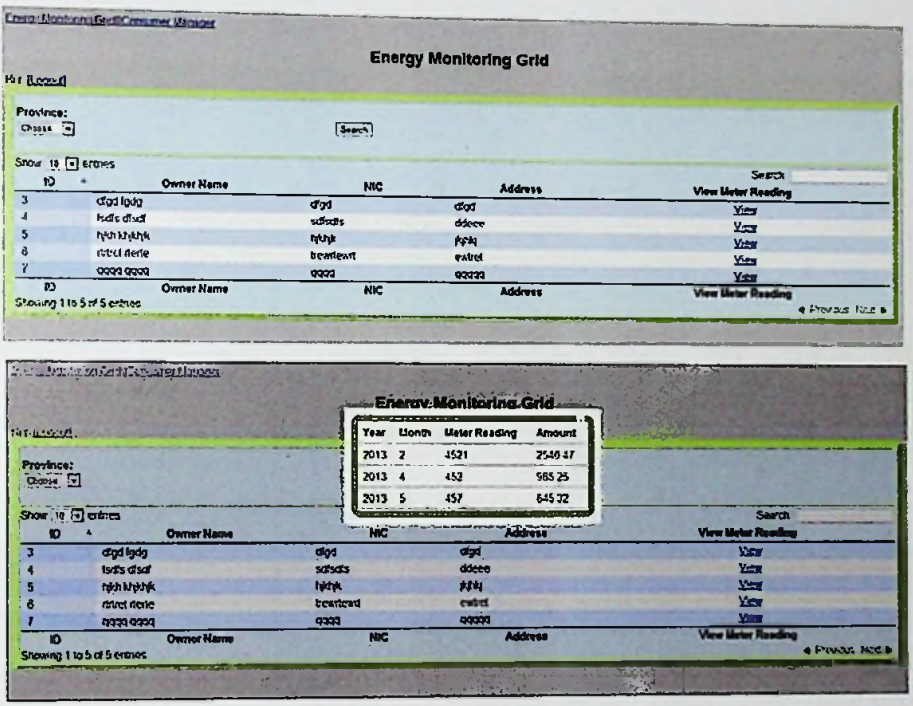

Figure 15 : Energy monitor grid

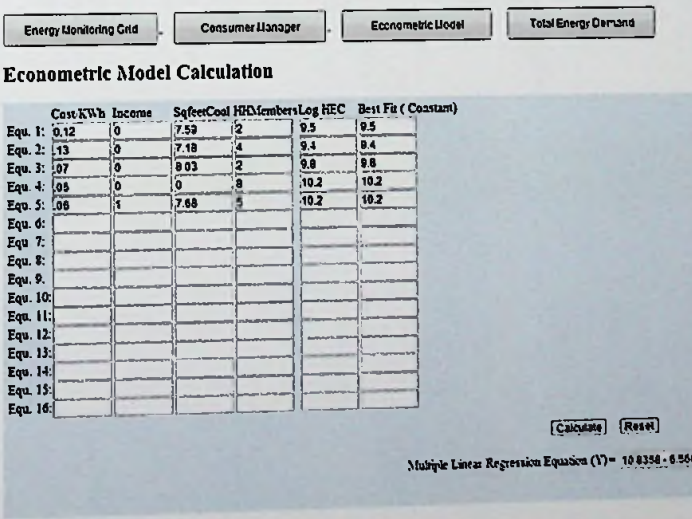

Figure 16: Econometric model

Total Energy Demand

The Administrator is also able to monitor total energy demand and the present consumption in each and every province, district, and DS division. This is a monitoring tool that CEB could track when the consumer over consumes electricity than his maximum demand. If a particular dashboard shows it would guide by selecting the location to the particular area and their exact location.

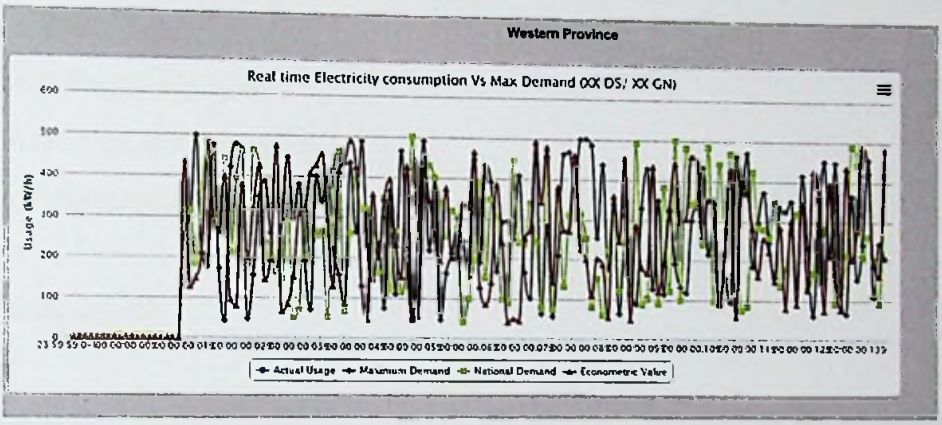

Figure 17 : Total Energy Demand in Two provinces

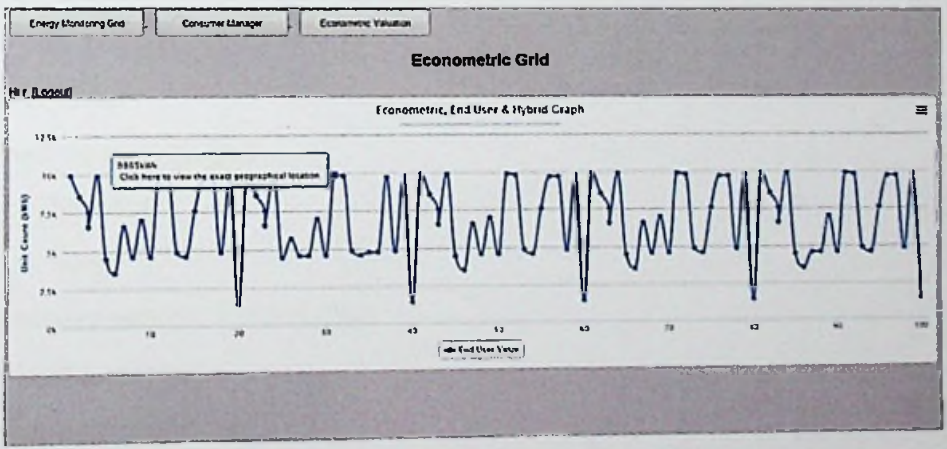

Figure 18 : Locations

Annex 5: Project Management

Project management is needed to ensure that the Project is on time as well as to ensure that the Project meets the underlined objectives, controls will be incorporated [27]. Standard methods have been applied for evaluating the progress of the assignment and this is accomplished through the following key steps:

- Project Status reviews - Monitoring progress against a project plan baseline and deliverable schedule
- Monthly Progress reviews
- Full Reporting and control for Projects
- Formal change control procedures

Annex 5.1 Status reports

The status report was provided for the panel as Interim Report which captured the following information [28].

- Project design
- Current status of project
    - Schedule
    - Scope
- Cumulative trends – Control chart
- Problems and issues
- Actions and resolutions

The detailed Monitoring & control plan used and control chart for project status tracking attached in Annex 5.8.

Annex 5.2.: Project Problem Reports

A simple form based procedure will be initiated at the commencement of the project to log, track and resolve all problems and issues that arise during the course of the project [29].

Project Problem Reports may be raised by any member of the project team and relate to any aspect of the project. They must be reviewed by a Project Manager or delegated person before being logged.

Examples include:

- Application software problems/errors
- Uncertainty over user or business requirements
- Alternatives for meeting user or business requirements
- Disagreement between project team members
- Schedule/resource problems
- Changes to project scope.

Project problems and/or issues logged through this procedure may be addressed in a number of ways

This was responsible for maintaining the Project Problem Reports' log. CEB could use the log on an ongoing basis after completion of the project as part of any internal support arrangements

Annex 5.3.: Change Control

Notwithstanding all the care taken to work out a detailed plan of execution, changes do occur, more often than not, to functional requirements, priority, and architecture and to many other parameters of the project. However, such changes have to be effectively controlled so as to minimize their impact on the deliverables. Changes have to be effectively controlled so as to minimize their impact on the deliverables. This is the objective of successful Change Management.

Annex 5.4.: Quality Management

It's the responsibility of the student to ensure that required quality standards are maintained at all levels. Any minor quality issue was rectified & resolved on site and all deviations were to be informed to the supervisor for prior approval

Annex 5.5.: Risk Management and Risk mitigation strategy

Risk Management during implementation involves identifying all the risks associated with the nature and complexity envisaged, and the control measures defined to manage these risks.

The risks associated in the implementation process and have taken counter measures to minimize the risk impact. Some of the issues relating to risk management for the system are attached herewith:

- Complexity resulting from the number and variety of activities.
- Need to see the impact on the solution.
- Visible and specific nature of the end product, that is, processes that work or does not work.
- Indefinite nature of the starting point.

Annex 5.6.: Scenario analysis

The scenario analysis [30] conducted based on the "Probability of the event" and "Impact of the event" is given below.

Risk Assessment	Likelihood	Impact	Risk factor	When
Delays in approval process with the CEB and Sustainable Energy Authority	2	2	4	Start-up
Low management commitment	3	2	6	Execution
Delays by CEB users/ Department Heads in providing information/ feedback/ acceptance	2	2	4	Execution
Unrealistic expectations on project outcomes/ benefits	4	3	12	Implementation
IT competence and experience of researcher	3	3	9	Implementation
Lack of knowledge of the business sector (CEB functionalities)	2	3	6	Planning
Lack of clarity in the policy decision on security and user accessibility structure	3	3	9	Execution

Table 15: Likelihood and impact of identified risks

Annex 5.7.: Risk Mitigation Plan

Project Risk	Severity	Potential Impact on the Project	Risk Mitigation Plan
Delays in approval process with the CEB and Sustainable Energy Authority	High	The timely commencement of the project hinges on the speedy mobilization of the Core team. Delays in mobilization thus pushes the project schedule by an equivalent duration	Mobilization of the resources
Low management commitment	Medium	The project success depends to a large extent on the commitment	Student motivation to complete the project kept at a higher level
Delays by CEB users/ Department Heads in providing information/ feedback/ acceptance	High	This would adversely affect the project schedule	Instructions from top management to all department heads CEB to provide information in the required time frame.
Unrealistic expectations on project outcomes/ benefits	High	This would adversely affect the acceptability of project outcomes	Clear communication on project scope to all concerned. Well-defined user expectations in the form of User Requirement document. Deep involvement and ownership of users in defining the To-Be processes and system requirements.
Change/ Creep in Scope	Medium	Lack of top management drive	Team would assess and freeze the scope on project sign off as the base line. However there could be a need for some change in the business process due to business compelling needs.
Lack of Consultant's knowledge of the business sector	Low	Long time in understanding the business process will delay the implementation schedules.	CEB will involve consultants with domain expertise and background in the project. This will help in implementation in reduced time frames.
Lack of clarity in the policy decision on security and user accessibility structure	Low	Security policies of the system	CEB would help in providing the necessary inputs in designing the policy relating to security and access controls at various levels.

Table 16: Risk mitigation plan

Annex 5.8.: Status reporting and controlling

Project Status Tracking & Reporting

To ensure that the Project is on time and budget as well as to ensure that the Project meets the underlined objectives, fortnightly progress review meetings with supervisor were arranged [31].

Fortnightly either met / had a conference meeting the Supervisor to discuss on the status as well as the future action plan and issues to be addressed.

Control chart

Given below is the format of the Control chart that will be used for the project [32].

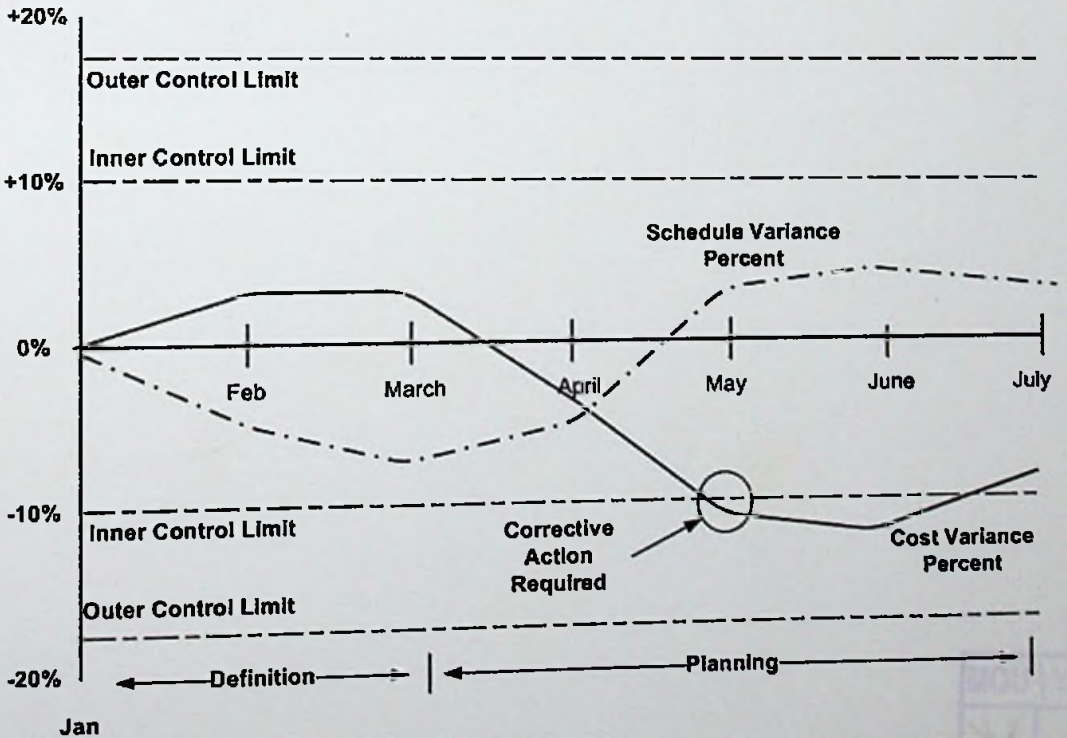

Figure 19: Control chart