

U.S. ARMY MEASUREMENT AND VERIFICATION (M&V) COSTING TOOLKIT

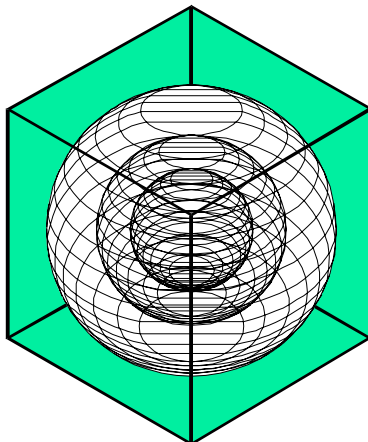
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Final Report

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ABSTRACT

This is the 2003 final report for the U.S. Army Monitoring and Verification (M&V) costs project. The purpose of this project is to develop a M&V Costing Toolkit to be used by the government or third party planners to design a M&V plan and to estimate the M&V costs associated with the verification of savings from the implementation of energy conservation measures in a building, or group of buildings. This report presents a general overview of the M&V costing process, various methods for monitoring and verifying savings, and a description of the M&V Costing Toolkit. In addition, examples of the use of the M&V Costing Toolkit will also be presented for thirteen scenarios, including the M&V of boilers, chillers, EMCS, and lighting retrofits.

Three M&V methods have been developed for this toolkit, including: a) monthly utility billing analysis, b) hourly or daily data analysis, and c) calibrated simulation, which is included under the data analysis method. With the exception of the monthly utility billing analysis, each method has several data collection options, including: a) using data loggers, b) using EMCS data and c) using utility interval data recorded by the utility supplier and transferred to the data analyst. Each of these methods is intended to be compatible with the IPMVP (2001) and ASHRAE's Guideline 14P (ASHRAE 2001). Additional references have been included that provide detailed descriptions of some of the M&V methods intended to be used with the report, as well as vendors of data acquisition equipment referred to in this report.

This M&V Costing Toolkit was developed using the MS Excel program. The toolkit consists of three MS Excel workbooks. The Utility.XLS workbook represents the monthly utility billing analysis method and the Project.XLS workbook represents the data analysis and calibrated simulation methods. The M&V Equipment Costs.XLS workbook contains the database of data acquisition equipment that is used in the Project.XLS workbook. Each workbook can be divided into two parts, including the cost summary and detailed costing information. Labor costs and weather information spreadsheets are included in both workbooks.

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1. INTRODUCTION

This is 2003 final report for the U.S. Army Monitoring and Verification (M&V) costing toolkit project. The Army has invested large sums of money in energy conservation projects over the years to reduce energy costs and reduce environmental impacts. Most recently, the primary instrument for financing these projects has been the Energy Savings Performance Contract (ESPC). The general idea behind ESPCs is that the initial capital investment is made by the ESPC contractor who is later paid by the government from the energy savings attributable to the project. An extremely important aspect of this financing concept is the Measurement and Verification (M&V) of the projected savings. In many cases, only minimal M&V is specified or performed. There are many reasons for this, including a general lack of knowledge about how to perform M&V and how much M&V costs.

1.1 Purpose of this Project

The purpose of this project is to develop a M&V Costing Toolkit to be used by the government or third party planners to design a M&V plan and to estimate M&V costs.

1.2 Contents of this Report

This report presents the description of the M&V Costing Toolkit. In addition, examples of the use of the M&V Costing Toolkit are also presented. In Section 2, a description of the M&V Costing Toolkit is presented. Next, a description of the distribution files is presented. In Section 4, instructions are presented for loading and using the files. Section 5 includes examples of the use of the toolkit, which includes a detailed description of one scenarios, and summaries of the remaining 12 scenarios. By using these examples, one can learn how to use the toolkit for most M&V costing situations. Sections 6 and 7 contain the summary and references.

2. DESCRIPTION OF THE TOOLKIT

2.1 Overview of the costing toolkit

This M&V Costing Toolkit was developed using the Microsoft Excel program. Below are the three files that contain the M&V Costing Toolkit.

- Project.xls
- Utility.xls
- M&V Equipment Costs.xls

The M&V Costing Toolkit has several options for M&V processing. For example, the Project.xls workbook (i.e., file) has three main options: using data loggers, using EMCS, and calibrated simulation. The Utility.xls workbook is for the monthly utility billing analysis. The M&V Equipment Costs.xls workbook is a database of all of the M&V equipment. The user should copy each Excel file to a new file name representative of a particular job, update the pointer to the file name, and then begin entering the required data into the costing portion of the spreadsheet. The summary of the expected cost for the M&V job can then be viewed on the summary spreadsheet.

2.2 Description of workbooks

In this section an overview of the workbooks and worksheets is presented. The M&V Costing Toolkit has been developed using Microsoft Excel spreadsheets. The Utility.xls and Project.xls workbooks are the files in which you work and store your data.

Each of these workbooks has several worksheets. These worksheets are basically divided into two parts: 1) detailed costing input spreadsheets, and 2) summary spreadsheets as indicated by the tabs that appear at the lower left corner of the spreadsheet.

Each of these workbooks then contains one or more options for the user to use in costing the M&V project. For example, in the Monthly Utility Billing Analysis section of the Toolkit (which was developed in 2001) can provide information about the gathering and processing of monthly utility billing information, weather information and the analysis. This information is input into the "Utility.xls" workbook after the user has copied it into a new file name that represents the project on which they are working. Additional information about the Monthly Utility Billing Analysis method is provided in the example section of this report.

In the "Project.xls" workbook, the user has three main M&V options, including: a) Using data loggers, b) Using an EMCS system, and c) calibrated simulation. The user must select the equipment necessary for the M&V project from a database of equipment. This database of equipment is located in the "Fort Hood M&V Equipment Costs.xls" workbook, which is linked to the "Project.xls" workbook. The user is also required to enter information about the gathering and processing of weather data. Finally, the user enters information regarding the baseline analysis, ongoing savings analysis, reporting, data recovery, and project close-out. Additional information about the Project.xls workbook is provided in the example section of this report.

Figure 1 presents a view of the Costing Summary spreadsheet that is used in both of the M&V workbooks. Each of the Costing Summary spreadsheets has a spreadsheet title in the upper left corner of the spreadsheet to indicate which spreadsheet is active as indicated. The user can change the type of spreadsheet by clicking on the tabs located at the bottom left of the spreadsheet. The choices are: Project_Summary, Project_Cost, Weather_Summary, Weather_Cost, and Labor_Cost.

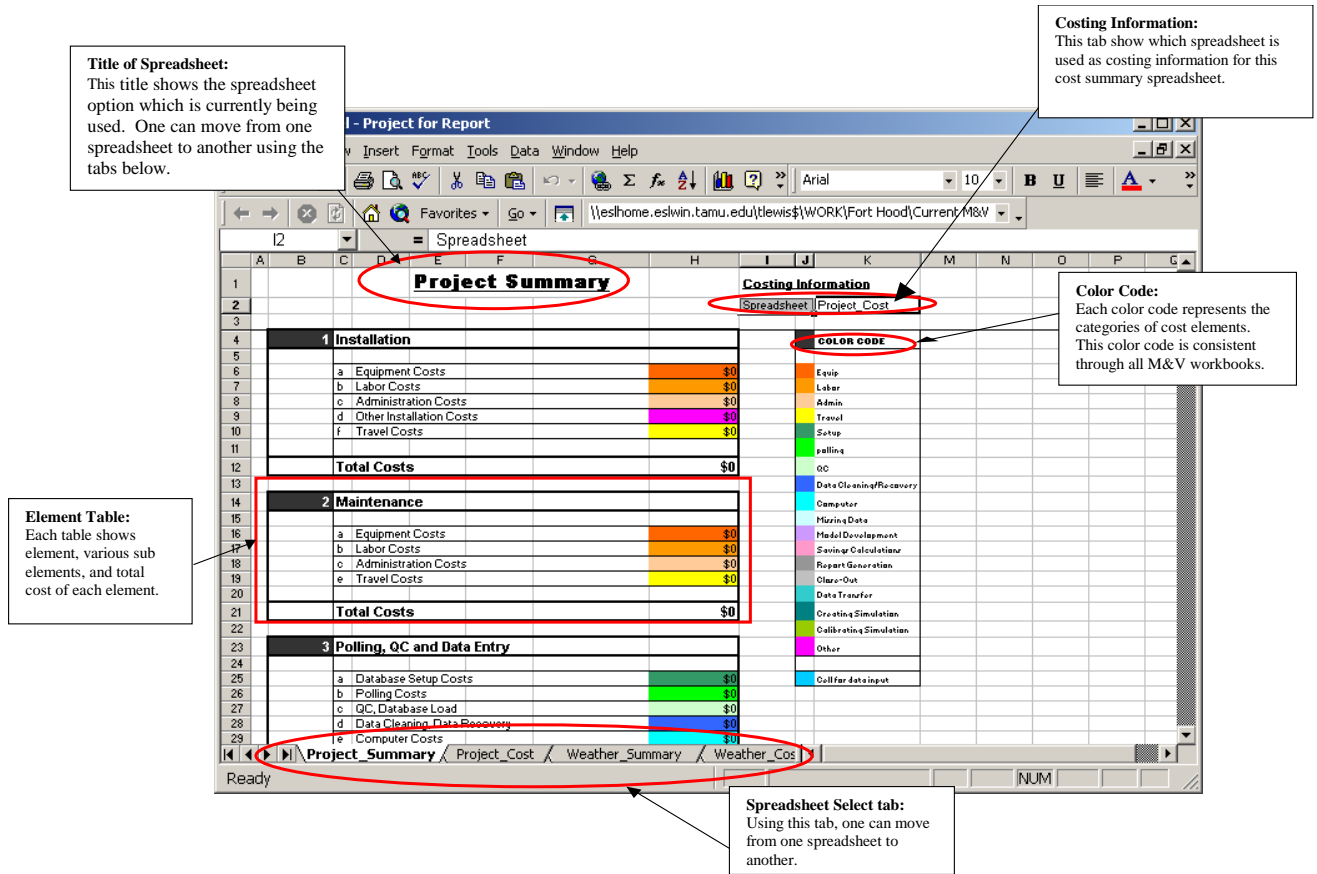


Figure 1: View of the Cost Summary Spreadsheet

In the upper right corner of the Costing Summary spreadsheet the Costing Information Input spreadsheet that is currently being used is indicated. This name should be pointing to the file the user wants to open.

All of the spreadsheets are color coded to allow for easier tracking of the major cost categories, including: equipment, labor, administration, travel, setup, polling, QC, data cleaning/recovery, computer costs, missing data costs, model development costs, savings calculation costs, report generation costs, close-out costs, data transfer costs, and other costs.

In the Project_Summary spreadsheet, these Summary costs are then grouped together under the major cost functions, including: 1) Installation, 2) Maintenance, 3) Polling, QC, and Data Entry, 4) Equipment Removal, 5) Data Recovery/Missing Data, 6) One-time Baseline/Post-retrofit Analysis, 7) Ongoing Savings Analysis, 8) Creating the Basic Simulation Input File, 9) Calibrating Simulation, 10) Use the Calibrated Simulation to Calculate Baseline, 11) Use the Calibrated Simulation to Calculate Ongoing Savings, 12) Reporting, 13) Close-out Data Transfer, 14) Weather Data, and finally an entry for Overhead and Profit, and Total Project Costs. Notice that on the Summary Cost spreadsheet, the only cell that the user needs to edit is the Overhead and Profit, since all other cells are references to other spreadsheets. All other cells point to other cells in the workbook, and therefore should not be changed.

Figure 2 shows the Costing Information Input spreadsheet (Project_Cost) for theProject.xls workbook. This spreadsheet is the primary spreadsheet for the entry of the detailed information that appears in the Project_Summary spreadsheet. The most commonly updated information is highlighted in blue. Less frequently updated information remains colorless. The other cell colors relate to the color coded cost categories.

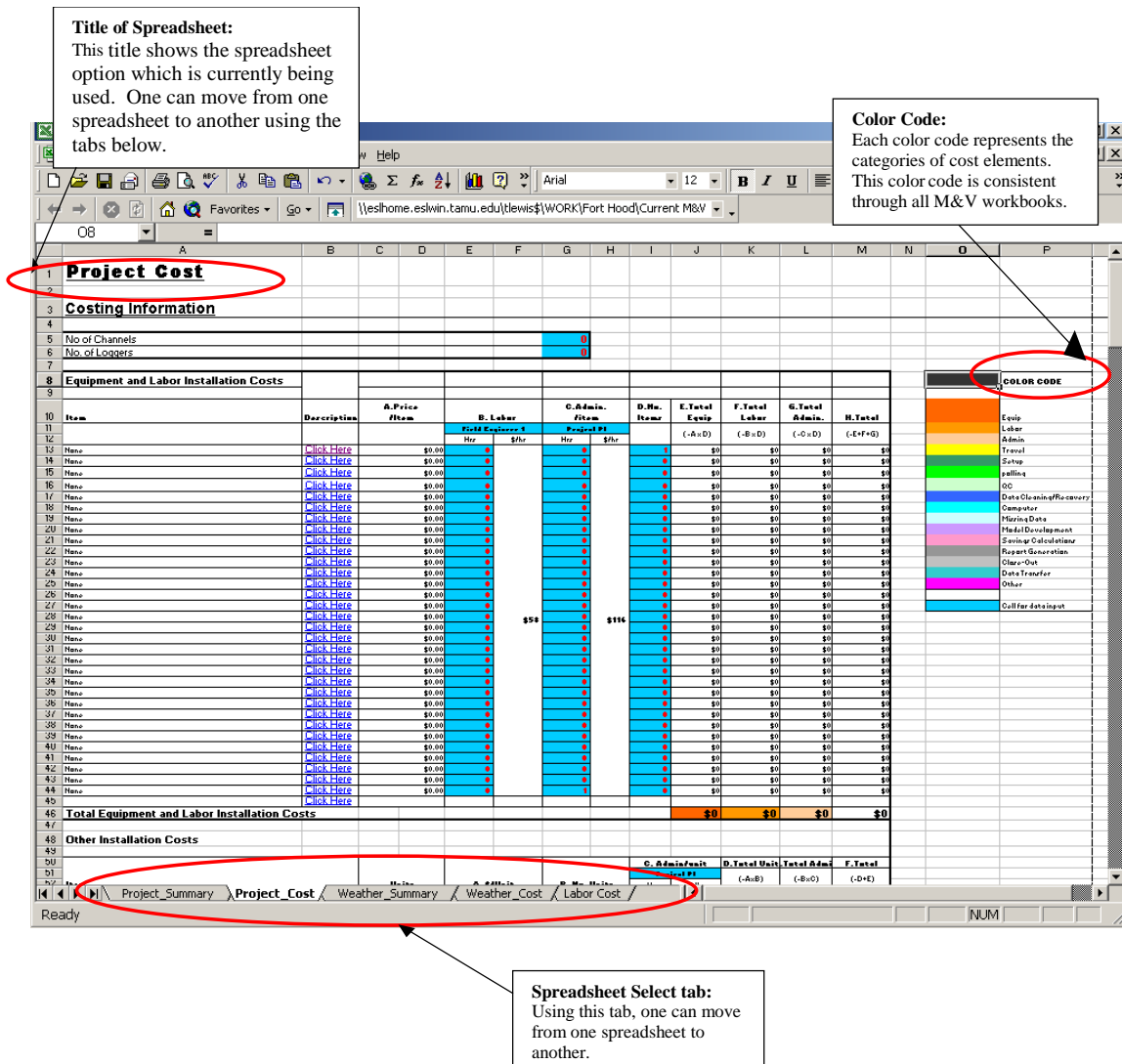


Figure 2: View of the Costing Information Input Spreadsheet

This spreadsheet is accessed by clicking on the Project_Cost tab located at the bottom left of the Project.xls Workbook.

2.2.1 Costing Information Input Spreadsheets

Each of the two workbooks includes two costing information input spreadsheets. Figure 2 shows the general screen view of the costing information input spreadsheet. The Project.xls workbook has a Project_Cost and a Weather_Cost information input spreadsheet. The Utility.xls workbook has its own Utility_Cost and a Weather_Cost information input spreadsheets.

2.2.2 Color Coding

To facilitate ease of use, certain costs categories have been color coded across all the spreadsheets as shown in Figure 3. The categories are used for easier tracking of the major cost categories, including: equipment, labor, administration, travel, setup, polling, QC, data cleaning/recovery, computer costs, missing data costs, model development costs, savings calculation costs, report generation costs, close-out costs, data transfer costs, and other costs.

- Hardware maintenance
- Polling, QC and database entry
- Equipment removal
- Data Recovery/Missing Data
- One time Baseline/Post Retrofit Analysis
- Ongoing Saving Analysis
- Creating the Basic Simulation Input File
- Calibrating Simulation
- Use the Calibrated Simulation to Calculate Baseline
- Use the Calibrated Simulation to Calculate Ongoing Savings
- Reporting
- Closeout/Data Transfer
- Summary

In the following sections each of the sub-sections of the Project.xls workbook are explained.

2.2.4.1 Project.xls Workbook: No. of Channels and Loggers

If data loggers or EMCS systems are going to be used for the M&V project, the user needs to enter the number of channels of data that are being recorded by the data logger (or EMCS) and the number of loggers, at the top of the costing information input spreadsheet for the Project.xls Workbook. These entries are used throughout the cost information input spreadsheet wherever the calculation depends upon the number of channels or number of data loggers at the job site. Figure 5 shows the data entry cells for the input of the number of channels and loggers. Everything in the Project.xls workbook is linked to this cell. Therefore, the user should make sure that these two cells accurately represent the number of channels and loggers for the project.

5	No. of Channels						12
6	No. of Loggers						1

Figure 5: Project.xls Workbook: No. of Channels and Loggers

2.2.4.2 Project.xls Workbook: Equipment and Labor Installation Costs

The next portion in the costing information input spreadsheet covers the input of information regarding the equipment cost and labor costs required to install the equipment as shown in Figure 6. This information is used in several other areas of the costing information input spreadsheet, where a ratio of the equipment cost is used for maintenance and later equipment removal.

In Figure 6 the default selection of “none” is shown for all of the item cells, however, a different type of equipment can be chosen by selecting the item cell and then selecting the desired piece of equipment from the drop-down menu. Some of the equipment that is included in the Project.xls equipment Cost Information Input spreadsheet include several different data loggers (which can be changed by the user), as well as portable data loggers, EMCS panels, Btu meters, temperature sensors, flow meters, condensate meters, current transformers (CTs), and voltage references (or PTs for potential transducers), watt hour transducers, phone line costs, conduit costs, several handheld instruments, and several other equipment categories. The price of the equipment will be automatically input into Column A once the equipment has been chosen.

In Column A the equipment costs for logger are shown, which represents a link to the equipment cost spreadsheet. The labor costs associated with the installation of each piece of equipment are entered by selecting the appropriate number of hours are then entered in the next column. The labor category is selected by

choosing the appropriate personnel from the labor selection cell (see Figure 8). This then automatically updates the single labor cost for all the equipment installation at that site.

In Figure 7 an example of the equipment is shown for the Enernet Model K20, which includes all manufacturer information, and a photograph of the logger, which is current as of August 2003.

Project Cost												
Costing Information												
Equipment and Labor Installation Costs												
Item	Description	A.Price /Item	B.Labor		C.Admin.		D.Hr. Items	E.Total Equip	F.Total Labor	G.Total Admin.	H.Total	
			Field Engineer 1 Hr	\$/hr	Project PI Hr	\$/hr						
13	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
14	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
15	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
16	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
17	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
18	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
19	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
20	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
21	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
22	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
23	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
24	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
25	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
26	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
27	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
28	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
29	None	Click Here	\$0.00		\$54		\$116	\$0	\$0	\$0	\$0	
30	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
31	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
32	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
33	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
34	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
35	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
36	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
37	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
38	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
39	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
40	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
41	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
42	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
43	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
44	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
45	None	Click Here	\$0.00					\$0	\$0	\$0	\$0	
46	Total Equipment and Labor Installation Costs								\$0	\$0	\$0	\$0

Figure 6: Project.xls Workbook: Equipment and Labor Installation Costs

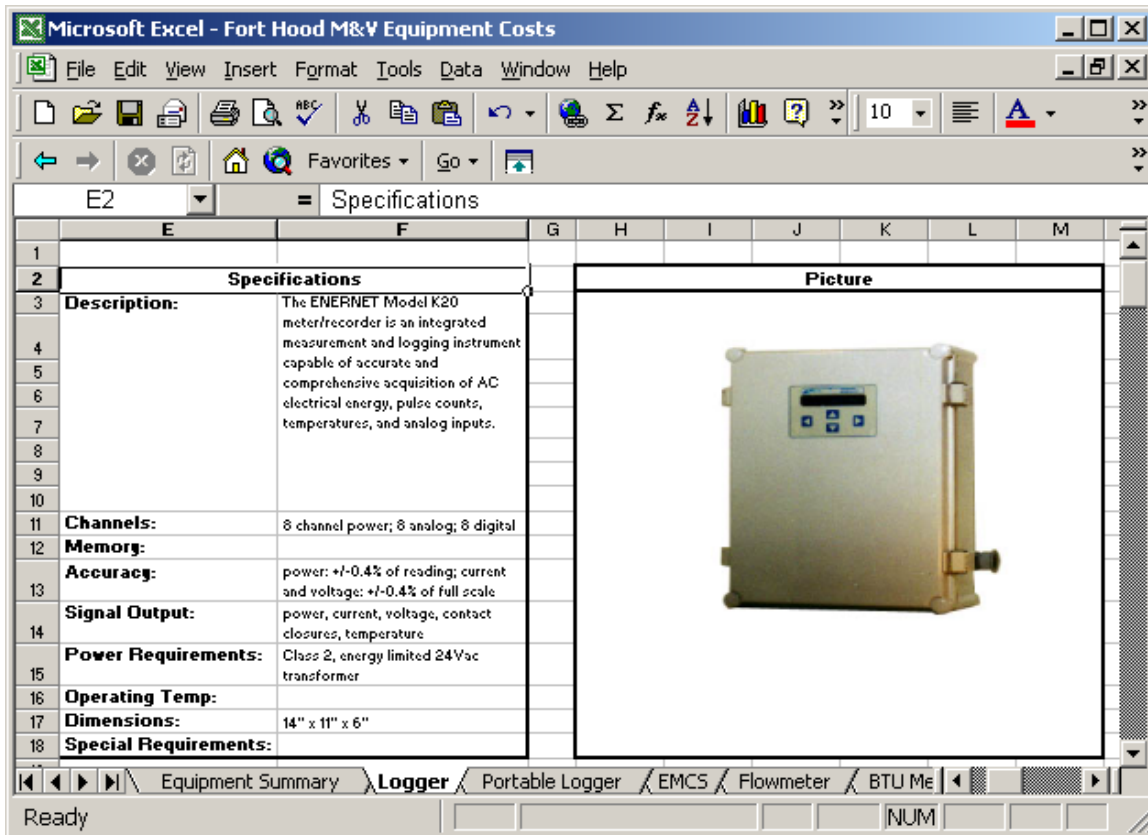


Figure 7: Example of Equipment Specifications in M&V Equipment Costs.xls

In Column C the administrative costs associated with the equipment installation are entered, as well as the choice of the appropriate labor category. Column D is used to enter the number of pieces of equipment that are being installed.

Column E is then the product of the equipment unit price times the number of units. The bottom of this column is then used for the equipment summary costs. Column F is the total labor costs for the product of Column B times Column D. Column G is the total administration costs, or Column C times Column D. Column H is then the total of the equipment cost, installation labor and administration costs associated with each piece of equipment. The bottom of this portion of the spreadsheet is then the equipment, labor and administration summary categories that are carried forward to the Project_Summary spreadsheet, as indicated by color.

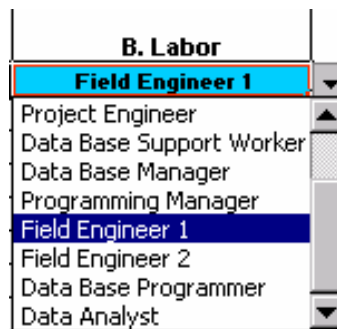


Figure 8: Project.xls Workbook: Choose a person in charge

2.2.4.3 Project.xls Workbook: Other Installation Costs

In most installations there is quite a bit of preparation required before the actual installation.

39	Other Installation Costs								
40									
41									
42				C. Admin/unit		D.Total Unit	E.Total Admin	F.Total	
43				Project PI		(=AxB)	(=BxC)	(=D+E)	
44	Item	Units	A. \$/Unit	B. No. Units	Hr	\$/hr			
45	PreMAP		\$0.00	1	12	\$116	\$0	\$1,386	\$1,386
46	Parts ordering, etc.		\$0.00	1	20		\$0	\$2,310	\$2,310
47	Other		\$0.00	0	0		\$0	\$0	\$0
48	Other		\$0.00	0	0		\$0	\$0	\$0
49									
50	Total Other Installation Costs						\$0	\$3,696	\$3,696
51									
52	Total Installation Costs								\$12,984

Figure 9: Project.xls Workbook: Other Installation Costs

This is quite often necessary for the preparation of the Preliminary Monitoring and Analysis Plan (PreMAP), the ordering of parts and supplies, and other costs as shown in Figure 9.

2.2.4.4 Project.xls Workbook: Travel Costs

There are often a number of visits to each site to inspect, install, maintain, and remove data logging or EMCS equipment. Each of these visits has an associated cost, as indicated in Figure 10. The costs associated with travel have been simplified to represent transportation, lodging, meals and misc. The transportation costs are entered into Column C as the \$/unit, these are then multiplied by the number of items (Column A) times the number of days (Column B). Lodging, meals and misc. are entered in a similar fashion. Column D is then used to totalize the travel costs by category. The bottom cell in Column D is then carried forward to the Summary spreadsheet.

54	Installation Travel Costs			
55				
56		A. Number of Items	B. Number of People, Days, etc.	D.Total
57				(=AxBxC)
58	Transporation	5	1	\$500
59	Lodging days	5	2	\$1,000
60	Meals per day	6	5	\$300
61	Misc.	0	0	\$0
62				
63	Total			\$1,800

Figure 10: Project.xls Workbook: Travel Costs

There are four sections where travel costs are used in the spreadsheet, including: Installation travel cost, PreMAP travel cost, Maintenance travel cost and Removal travel cost. Every travel cost table has the same format as that shown in Figure 10.

2.2.4.5 Project.xls Workbook: Maintenance and Labor Costs per year

The next section of the Costing Information Input for the Project.xls Workbook is the information needed for maintenance of the data loggers, EMCS, sensors, etc. The table that is provided in this section (see Figure 11) is similar in format to the table in the Equipment and Labor Installation Costs. In the maintenance cost input table the user inputs a percent (%) value for the cost of any anticipated annual equipment replacements for each piece of equipment, as well as the associated labor and administrative hours spent on maintenance. The spreadsheet then calculates the total equipment costs, labor costs, administrative costs and total maintenance costs. Travel associated with the maintenance of the site will also need to be entered.

76 Maintenance and Labor Costs Per Year												
77	A.Price /Item		B.Labor		C.Admin. /Item		D.No. Items	E.Total Equip.	F.Total Labor	G.Total Admin.	H.Total	
78 Item	%	Price	Field Engineer 1		Project CoPI			(=A X D)	(=B X D)	(=C X D)	(=E+F+G)	
79			Hrs	\$/hr	Hrs	\$/hr						
81	10%	\$279.50	2		0.2		1	\$280	\$116	\$23	\$418	
82	10%	\$184.50	2		0.2		0	\$0	\$0	\$0	\$0	
83	10%	\$124.50	2		0.2		0	\$0	\$0	\$0	\$0	
84	10%	\$74.50	2		0.2		0	\$0	\$0	\$0	\$0	
85	10%	\$0.00	2		0.2		0	\$0	\$0	\$0	\$0	
86	10%	\$0.00	2		0.2		0	\$0	\$0	\$0	\$0	
87	10%	\$0.00	2		0.2		0	\$0	\$0	\$0	\$0	
88	10%	\$50.00	2		0.2		0	\$0	\$0	\$0	\$0	
89	30%	\$21.00	2		0.2		4	\$84	\$462	\$92	\$638	
90	30%	\$180.00	4		0.2		2	\$360	\$462	\$46	\$868	
91	30%	\$150.00	4		0.2		0	\$0	\$0	\$0	\$0	
92	30%	\$255.00	4		0.2		0	\$0	\$0	\$0	\$0	
93	0%	\$0.00	2	\$58	0.2		1	\$0	\$116	\$23	\$139	
94	30%	\$540.00	4		0.2		0	\$0	\$0	\$0	\$0	
95	10%	\$15.00	1		0.1		6	\$90	\$347	\$69	\$506	
96	10%	\$17.50	1		0.1		1	\$18	\$58	\$12	\$87	
97	10%	\$39.40	1		0.1		0	\$0	\$0	\$0	\$0	
98	10%	\$0.70	0.5		0.1		1	\$1	\$29	\$12	\$41	
99	0%	\$0.00	0.1		0.1		1	\$0	\$6	\$12	\$17	
100	20%	\$0.00	0.2		0.1		0	\$0	\$0	\$0	\$0	
101	20%	\$0.00	0.2		0.1		0	\$0	\$0	\$0	\$0	
102	20%	\$0.00	0.2		0.1		0	\$0	\$0	\$0	\$0	
103	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0	
104	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0	
105	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0	
106	Total Costs								\$832	\$1,594	\$289	\$2,714

Figure 11: Project.xls Workbook: Maintenance and Labor Costs Per Year

2.2.4.6 Project.xls Workbook: Polling, QC and Data entry costs

The next screen allows the user to input costs associated with the polling, quality control (QC), and data entry associated with each data channel, and/or logger (see Figure 12). These costs begin with setup costs that are associated with each data logger or EMCS panel and usually occur once in the beginning of the project. For example, the cost of programming any automated polling software, setting up the database channels, etc. For each of the costs in this section of the spreadsheet there is an entry for supply costs, which may represent expendables related to this function. The supply units for the setup costs, polling costs, QC/Database, data cleaning, and computer maintenance are all tied to either the “per channel” or “per logger” count. The number of units for “other” is allowed to be defined by the user. The user then needs to define the labor and administrative salary category, the hours associated with each task, and the number of times each year that this task is performed.

120 Polling, QC and Data Entry Costs													
121	A. Unit		B. Supply		C. Labor		D. Admin/unit		E. No. Per yr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
122 Item			Data Base Support Worker		Project PI					(=B x E)	(=C x E)	(=D x E)	(=F+G+H)
123		No. Unit	\$/Unit	Hrs	\$/hr	Hrs	\$/hr						
125	Setup Costs	12	\$0.00	0.5		0.2		1	\$0	\$20	\$23	\$43	
126	Polling Costs	Per Logger	1	\$0.00	0.25		0.1	52	\$0	\$526	\$601	\$1,126	
127	QC, Database Load	Per Channel	12	\$0.00	0.25	\$40	0.1	52	\$0	\$526	\$601	\$1,126	
128	Data Cleaning	Per Channel	12	\$0.00	1			1	\$0	\$40	\$116	\$156	
129	Computer Maintenance	Per Month	12	\$1.00	0.25		0.1	12	\$144	\$121	\$139	\$404	
130	other		0	\$0.00	0		0	0	\$0	\$0	\$0	\$0	
131													
132	Total Costs									\$144	\$1,233	\$1,478	\$2,855

Figure 12: Project.xls Workbook: Polling, QC and Data Entry Costs

The spreadsheet then calculates the supply costs, labor costs, administrative costs and total costs associated with the polling, QC and data base entry.

2.2.4.7 Project.xls Workbook: Equipment Removal Costs

The equipment removal costs is the next section of the Costing Information Input (see Figure 13). In a similar fashion to the maintenance costs, these costs are related to the original equipment costs using a percentage (%) designation. To assign costs to this section of the spreadsheet, the user enters a percentage value for the removal of the equipment (based on the original cost of the equipment), the labor and administration categories, and the hours associated with this task for labor and administrative categories. Since this is a one-time cost there is no entry for the number of times this occurs. The spreadsheet then calculates the total

equipment costs, labor costs, administrative cost and total costs associated with the equipment removal. Travel costs associated with the equipment may also need to be entered using the previously described section on travel.

Equipment Removal Costs												
Item	A.Equip. Price/Item		B.Labor		C.Admin. /Item		D.No. Rem	E.Total Equip.	F.Total Labor	G. Total Admin	H. Total	
	%	Price	Hrs	\$/hr	Hrs	\$/hr						
139	0%	\$0	4		0.2		1	\$0	\$162	\$23	\$185	
140	0%	\$0	4		0.2		0	\$0	\$0	\$0	\$0	
141	0%	\$0	4		0.2		0	\$0	\$0	\$0	\$0	
142	0%	\$0	4		0.2		0	\$0	\$0	\$0	\$0	
143	0%	\$0	2		0.2		0	\$0	\$0	\$0	\$0	
144	0%	\$0	2		0.2		0	\$0	\$0	\$0	\$0	
145	0%	\$0	2		0.2		0	\$0	\$0	\$0	\$0	
146	0%	\$0	4		0.2		0	\$0	\$0	\$0	\$0	
147	0%	\$0	4		0.1		4	\$0	\$647	\$46	\$693	
148	0%	\$0	4		0.1		2	\$0	\$323	\$23	\$347	
149	0%	\$0	4		0.1		0	\$0	\$0	\$0	\$0	
150	0%	\$0	4	\$40	0.1	\$116	0	\$0	\$0	\$0	\$0	
151	0%	\$0	2		0.1		1	\$0	\$81	\$12	\$92	
152	0%	\$0	2		0.1		0	\$0	\$0	\$0	\$0	
153	0%	\$0	1		0.1		6	\$0	\$243	\$69	\$312	
154	0%	\$0	1		0.1		1	\$0	\$40	\$12	\$52	
155	0%	\$0	1		0.1		0	\$0	\$0	\$0	\$0	
156	0%	\$0	0.5		0.1		1	\$0	\$20	\$12	\$32	
157	0%	\$0	0.25		0.1		0	\$0	\$0	\$0	\$0	
158	0%	\$0	0.25		0.1		0	\$0	\$0	\$0	\$0	
159	0%	\$0	0.25		0.4		0	\$0	\$0	\$0	\$0	
160	0%	\$0	0		0		0	\$0	\$0	\$0	\$0	
161	0%	\$0	0		0		0	\$0	\$0	\$0	\$0	
162	Total Costs								\$0	\$1,516	\$196	\$1,712

Figure 13: Project.xls Workbook: Equipment Removal Costs

2.2.4.8 Project.xls Workbook: Data Recovery/Missing Data

The next section of the spreadsheet allows the user to enter costing information that is related to the recovery of bad or missing data (see Figure 14). This occurs often in a monitoring project when inappropriate scaling factors are assigned to a channel and need to be corrected. Likewise, periods of missing data may need to be removed and/or replaced with synthesized or imputed data. In this section the user defines the appropriate labor and administrative categories, and the hours associated with the data recovery or missing data tasks. A category has been reserved for “other” costs that can be defined by the user. Since these tasks can occur at different frequencies throughout the year, the user is allowed to enter the number of times per year that each task occurs.

Data Recovery/Missing Data													
Item	A. Unit	B.Supply		C.Labor		D.Admin/unit		E. No. Per yr	F.Total Supply	G.Total Labor	H. Total Admin	I. Total	
		No. Unit	\$/Unit	Hrs	\$/hr	Hrs	\$/hr						
181	Per Channel	12	\$1.00	0		1		1	\$12	\$323	\$116	\$451	
182	Per Channel	12	\$1.00	0	\$40	1	\$116	1	\$12	\$323	\$116	\$451	
183	other	0	\$0.00	0		0		0	\$0	\$0	\$0	\$0	
184													
185	Total Costs									\$24	\$647	\$231	\$902

Figure 14: Project.xls Workbook: Data Recovery/Missing Data

2.2.4.9 Project.xls Workbook: One Time Baseline/Post Retrofit Analysis

This section of the spreadsheet allows the user to enter costs associated with the creation of baseline statistical models that are based on different channels of data (see Figure 15). In a similar fashion to the other functions a category for supplies has been reserved. The tasks associated with the one-time baseline or post retrofit analysis include setup costs (based on each logger), model development costs, and other costs. To use this portion of the spreadsheet, the user chooses the appropriate labor and administration category, the number of models that are being developed and assigned the appropriate time in hours associated with the tasks shown. The spreadsheet then calculates the supply costs, labor costs, administrative costs and total costs.

One Time Baseline/Post Retrofit Analysis												
Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per yr	F. Total Supply (=B x E)	G. Total Labor (=C x E)	H. Total Admin (=D x E)	I. Total (=F+G+H)
		No. Unit	\$/Unit	Data Analyst		Project PI						
				Hrs	\$/Hr	Hrs	\$/Hr					
192 Setup Costs		1	\$1.00	2		1		1	\$1	\$116	\$116	\$232
193 Model Development Costs	Model	4	\$5.00	8	\$58	0.5	\$116	1	\$20	\$462	\$58	\$540
194 other		0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
195												
196 Total Costs									\$21	\$578	\$173	\$772

Figure 15 Project.xls Workbook: One Time Baseline/Post Retrofit Analysis

2.2.4.10 Project.xls Workbook: Ongoing Savings Analysis

This section of the spreadsheet allows the user to enter costs associated with the ongoing savings analysis (see Figure 16). Usually, this is required since the analyst that is calculating the savings must apply the baseline models against either a weather normalized year or against the actual post-retrofit weather data to calculate the savings associated with the retrofit measure. In some cases this may require the creation and application of a post-retrofit model to fill-in missing data in the post-retrofit period, costing categories for the savings calculation and another cost category have also been added. To use this section of the spreadsheet, the user chooses the labor and administrative categories, chooses the number of post-retrofit models and savings calculations, and assigns an hourly labor and administrative charge to each of these tasks, as well as the number of times per year that this task must be performed.

Ongoing Savings Analysis												
Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per yr	F. Total Supply (=B x E)	G. Total Labor (=C x E)	H. Total Admin (=D x E)	I. Total (=F+G+H)
		No. Unit	\$/Unit	Data Analyst		Project PI						
				Hrs	\$/Hr	Hrs	\$/Hr					
204 Post-Retrofit Model Costs		4	\$1.00	8		1		1	\$4	\$462	\$116	\$582
205 Savings Calculations		4	\$5.00	8	\$58	0.5	\$116	12	\$240	\$347	\$693	\$1,280
206 other		0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
207												
208 Total Costs									\$244	\$609	\$609	\$1,861

Figure 16: Project.xls Workbook: Ongoing Savings Analysis

2.2.4.11 Project.xls Workbook: Creating the Basic Simulation Input File

In Figure 17 the costs associated with the creation of a calibrated simulation are entered into the spreadsheet. Assuming that the DOE-2 program is used, these include the creation of the LOADS, SYSTEMS, PLANT and ECONOMICS portion of the input file. The user enters any supplies, labor, administrative labor costs, and the associated times each year these costs occur. The spreadsheet then calculates the total supplies, labor, administration and total costs.

Creating the Basic Simulation Input File												
Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per yr	F. Total Supply (=B x E)	G. Total Labor (=C x E)	H. Total Admin (=D x E)	I. Total (=F+G+H)
		No. Units	\$/Unit	Data Analyst		Project PI						
				Hrs	\$/Hr	Hrs	\$/Hr					
192 Creating LOADS	Files	1	\$0.00	30		1		1	\$0	\$1,733	\$116	\$1,840
193 Creating SYSTEMS	Files	1	\$0.00	10		1		1	\$0	\$578	\$116	\$693
194 Creating PLANT	Files	1	\$0.00	5	\$58	1	\$116	1	\$0	\$289	\$116	\$404
195 Creating ECONOMICS	Files	1		1		1		1	\$0	\$58	\$116	\$173
196 Other		0		0		0		0	\$0	\$0	\$0	\$0
197												
198 Total Costs									\$0	\$2,657	\$462	\$3,119

Figure 17: Calibrated Simulation: Creating the Basic Simulation Input File

2.2.4.12 Project.xls Workbook: Calibrating the Simulation

In Figure 18 the costs associated with calibrating the simulation are entered, which are similar in format to those shown in Figure 17 with the exception that there are several procedures associated with the LOADS calibration, including the calibration of the building dimensions, schedules, envelope construction, as well as the packing of a weather tape with on-site weather data, and the calibration of the SYSTEMS and PLANT input files.

200	Calibrating the Simulation												
201													
202	Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per gr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
203					Data Analyst		Project PI			(=B×E)	(=C×E)	(=D×E)	(=F+G+H)
204			No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
205	Calib. LOADS Dimension	Procedure	1	\$0.00	10		1		1	\$0	\$578	\$116	\$693
206	Calib. LOADS Schedules	Procedure	1	\$0.00	5		1		1	\$0	\$289	\$116	\$404
207	Calib. LOADS Int. Env. Con	Procedure	1	\$0.00	5		1		1	\$0	\$289	\$116	\$404
208	Packing Weather Tape	Procedure	1	\$10.00	5	\$58	1	\$116	1	\$10	\$289	\$116	\$414
209	Calib. SYSTEMS	Procedure	1	\$0.00	10		1		1	\$0	\$578	\$116	\$693
210	Calib. PLANT	Procedure	1	\$0.00	10		1		1	\$0	\$578	\$0	\$578
211	Other		0		0		0		0	\$0	\$0	\$0	\$0
212													
213	Total Costs									\$10	\$2,539	\$578	\$3,186

Figure 18: Project.xls Workbook: Creating the Calibrated Simulation

2.2.4.13 Project.xls Workbook: Use of Calibrated Simulation to Calculate Baseline

Once the simulation is calibrated it is then used to calculate the baseline for the project, which includes the costs shown in Figure 19. These include the setup costs, model development costs and baseline calculation costs.

215	Use the Calibrated Simulation to Calculate Baseline												
216													
217	Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per gr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
218					Data Analyst		Project PI			(=B×E)	(=C×E)	(=D×E)	(=F+G+H)
219			No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
220	Setup Costs		1	\$0.00	4		1		1	\$0	\$231	\$116	\$347
221	Model Development Costs		1	\$0.00	8	\$58	1	\$116	1	\$0	\$462	\$116	\$578
222	Calculate Baseline		1	\$0.00	2		1		1	\$0	\$116	\$116	\$231
223	other		0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
224													
225	Total Costs									\$0	\$809	\$347	\$1,155

Figure 19: Project.xls Workbook: Use the Calibrated Simulation to Calculate Baseline

2.2.4.14 Project.xls Workbook: Use the Calibrated Simulation to Calculate Ongoing Savings

Finally, once the retrofits have been applied to the project, the costs associated with the calculation of savings need to be entered, as shown in Figure 20. These include any costs associated with the model development or refinement, and the savings calculations.

227	Use the Calibrated Simulation to Calculate Ongoing Savings												
228													
229	Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per gr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
230					Data Analyst		Project Engineer			(=B×E)	(=C×E)	(=D×E)	(=F+G+H)
231			No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
232	Model Development Costs		1	\$1.00	0		0.5	\$58	1	\$1	\$462	\$29	\$492
233	Savings Calculations		1	\$1.00	1	\$58	0.5	\$58	12	\$12	\$693	\$347	\$1,052
234	other		0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
235													
236	Total Costs									\$13	\$1,155	\$375	\$1,543

Figure 20: Project.xls Workbook: Use the Calibrated Simulation to Calculate Ongoing Savings

2.2.4.15 Project.xls Workbook: Reporting

The next section of the spreadsheet allows the user to input costing information that relates to the generation of savings or consumption reports (see Figure 21). The costs associated with the reporting of information include a setup cost for each site (i.e., per logger or EMCS panel), report generation costs per site or logger, and a user-defined other cost. In a similar fashion to the other costs, the user is allowed to also enter a supply cost. To use this section of the spreadsheet the user selects the labor and administrative categories, the labor and administrative hours associated with each task, and the number of times per year this task is performed. The spreadsheet then calculates the supply costs, labor costs, administrative costs and total costs associated with the reporting function.

210	Reporting												
211													
212	Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per yr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
213					Data Analyst		Project PI			(=B x E)	(=C x E)	(=D x E)	(=F+G+H)
214			No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
215	Setup Costs		1	\$1.00	2		1		1	\$1	\$116	\$116	\$232
216	Report Generation Costs		1	\$1.00	0.5	\$58	0.25	\$116	12	\$12	\$347	\$347	\$705
217	other		0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
218													
219	Total Costs									\$13	\$462	\$462	\$937

Figure 21: Project.xls Workbook: Reporting

2.2.4.16 Project.xls Workbook: Close-out, Data Transfer

The next section of the report involves costs associated with the close-out and data transfer tasks (see Figure 22). These tasks are often required when data from an M&V project are to be transferred to another job. The tasks assigned to the section of the spreadsheet include the close-out costs, data transfer costs, and other costs. Supply costs associated with these tasks can also be defined by the user. To use this section of the spreadsheet, the user enters the labor category, administrative category, labor and administrative hours associated with each task, and the number of times each task is to be performed. The spreadsheet then calculates the supply costs, labor, administrative costs and total costs.

221	Close-out, Data Transfer												
222													
223	Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per yr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
224					Data Analyst		Project PI			(=B x E)	(=C x E)	(=D x E)	(=F+G+H)
225			No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
226	Close-Out	Per Logger	1	\$1.00	1		1		1	\$1	\$58	\$116	\$174
227	Data Transfer	Per Channel	12	\$1.00	2	\$58	1	\$116	1	\$12	\$116	\$116	\$243
228	other		0	\$1.00	0		0		0	\$0	\$0	\$0	\$0
229													
230	Total Costs									\$13	\$173	\$231	\$417

Figure 22: Project.xls Workbook: Close-out, Data Transfer

2.2.4.17 Project.xls Workbook: Cost Summary

The next section of the report shows the summary costs. It is reached using the tabs at the bottom of the spreadsheet. In this section a summary of the costs is provided, which have previously been calculated in each of the previous sections as shown in Figure 23. In this section of the report the user only needs to update the Overhead and profits associated with the project, which are then applied to the summarized project costs.

Cost Summary		
Project	1 Installation	\$0
	2 Maintenance	\$0
	3 Polling, QC and Data Entry	\$0
	4 Equipment Removal	\$0
	5 Data Recovery/Missing Data	\$0
	6 One Time Baseline/Post Retrofit Analysis	\$0
	7 Ongoing Savings Analysis	\$0
	8 Creating the Basic simulation Input File	\$0
	9 Calibrating Simulation	\$0
	10 Use the Calibrated Simulation to Caculate Baseline	\$0
	11 Use the Calibrated Simulation to Caculate Ongoing	\$0
	12 Reporting	\$0
	13 Close-out, Data Transfer	\$0
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$845
		22%
Total Project Costs		\$4,688

Figure 23: Project.xls Workbook: Cost Summary

2.2.5 Costing Information Input for the Utility.xls Workbook

The costing information input spreadsheet for the Utility.xls Workbook was defined and 2001, and therefore is different than the input for the Project.xls Workbook since there is no cost associated with the installation, maintenance and/or removal of the data logging equipment. The costing information input spreadsheet for the Utility.xls workbook contains the following elements:

- Data transfer, QC and data entry
- Data Recovery/Missing Data
- One time Baseline/Post Retrofit Analysis
- Ongoing Saving Analysis
- Reporting
- Closeout/Data Transfer

2.2.5.1 Utility.xls Workbook: Data Transfer, QC and Data Entry Costs

The first section that appears on the data information input spreadsheet for the Utility.xls Workbook involves the actual transfer of data from the utility to the M&V provider. In this section the user can input the number of units for setup costs, any associated supply costs, and labor and administrative categories (see Figure 24). The user then can enter values for the data transfer, QC and database loading, data cleaning, any associated computer costs and other costs. For each of these categories the user enters the hour of labor associated with each item, the administrative hours, and the number of times each year that the process takes place. The spreadsheet then calculates the supply costs, the labor costs, the administration costs and the total costs.

5 Data Transfer, QC and Data Entry Costs												
6												
7 Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per yr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
8				Data Base Support Worker	Project PI				(=B x E)	(=C x E)	(=D x E)	(=F+G+H)
9		No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
10	Setup Costs	0	\$0.00	4		0.5		1	\$0	\$162	\$58	\$219
11	Data Transfer	0	\$0.00	0.5		0.1		52	\$0	\$1,051	\$601	\$1,652
12	QC Database Load	0	\$0.00	0.1	\$40	0.1	\$116	52	\$0	\$210	\$601	\$811
13	Data Cleaning	0	\$0.00	10		1		1	\$0	\$404	\$116	\$520
14	Computer Costs	Per Month	12	\$10.00	0	0		12	\$1,440	\$0	\$0	\$1,440
15	other	0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
16												
17	Total Costs								\$1,440	\$1,827	\$1,374	\$4,642

Figure 24: Utility.xls Workbook: Data Transfer, QC and Data Entry Costs

2.2.5.2 Utility.xls Workbook: Data Recovery/Missing Data

The next section of the spreadsheet allows the user to enter costing information that is related to the recovery of bad or missing data (see Figure 25). This occurs often in a monitoring project when inappropriate scaling factors are assigned to a channel and need to be corrected. Likewise, periods of missing data may need to be removed and/or replaced with synthesized or imputed data. In this section the user defines the appropriate labor and administrative categories, and the hours associated with the data recovery or missing data tasks. A category has been reserved for “other” costs that can be defined by the user. Since these tasks can occur at different frequencies throughout the year, the user is allowed to enter the number of times per year that each task occurs.

20	Data Recovery/Missing Data												
21													
22	Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per gr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
23					Data Base Support Worker		Project PI			(=B x E)	(=C x E)	(=D x E)	(=F+G+H)
24			No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
25	Data Recovery		0	\$1.00	8		1		1	\$0	\$323	\$116	\$439
26	Missing Data		12	\$1.00	8	\$40	1	\$116	1	\$12	\$323	\$116	\$451
27	other		0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
28													
29	Total Costs									\$12	\$647	\$231	\$890

Figure 25: Utility.xls Workbook: Data Recovery/Missing Data

2.2.5.3 Utility.xls Workbook: One Time Baseline/Post Retrofit Analysis

This section of the spreadsheet allows the user to enter costs associated with the creation of baseline statistical models that are based on different channels of data (see Figure 26). In a similar fashion to the other functions a category for supplies has been reserved. The tasks associated with the one-time baseline or post retrofit analysis include setup costs (based on each logger), model development costs, and other costs. To use this portion of the spreadsheet, the user chooses the appropriate labor and administration category, the number of models that are being developed and assigned the appropriate time in hours associated with the tasks shown. The spreadsheet then calculates the supply costs, labor costs, administrative costs and total costs.

31	One Time Baseline/Post Retrofit Analysis												
32													
33	Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per gr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
34					Data Analyst		Project PI			(=B x E)	(=C x E)	(=D x E)	(=F+G+H)
35			No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
36	Setup Costs		1	\$0.00	4		1		1	\$0	\$231	\$116	\$347
37	Model Development Costs	Model	1	\$0.00	8	\$58	1	\$116	1	\$0	\$462	\$116	\$578
38	Savings Calculations		1	\$0.00	2		1		12	\$0	\$1,386	\$1,386	\$2,772
39	other		0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
40													
41	Total Costs									\$0	\$2,079	\$1,617	\$3,696

Figure 26: Utility.xls Workbook: One Time Baseline/Post Retrofit Analysis

2.2.5.4 Utility.xls Workbook: Ongoing Savings Analysis

This section of the spreadsheet allows the user to enter costs associated with the ongoing savings analysis (see Figure 27). Usually, this is required since the analyst that is calculating the savings must apply the baseline models against either a weather-normalized year or against the actual post-retrofit weather data to calculate the savings associated with the retrofit measure. In some cases this may require the creation and application of a post-retrofit model to fill-in missing data in the post-retrofit period, costing categories for the savings calculation and another cost category have also been added. To use this section of the spreadsheet, the user chooses the labor and administrative categories, chooses the number of post-retrofit models and savings calculations, and assigns an hourly labor and administrative charge to each of these tasks, as well as the number of times per year that this task must be performed.

43	Ongoing Savings Analysis												
44													
45	Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per gr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
46					Data Analyst		Project Engineer			(=B x E)	(=C x E)	(=D x E)	(=F+G+H)
47			No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
48	Model Development Costs		1	\$1.00	2		0.5		12	\$12	\$1,386	\$347	\$1,745
49	Savings Calculations		1	\$1.00	1	\$58	0.5	\$58	12	\$12	\$693	\$347	\$1,052
50	other		0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
51													
52	Total Costs									\$24	\$2,079	\$693	\$2,796

Figure 27: Utility.xls Workbook: Ongoing Savings Analysis

2.2.5.5 Utility.xls Workbook: Reporting

The next section of the spreadsheet allows the user to input costing information that relates to the generation of savings or consumption reports (see Figure 28). The costs associated with the reporting of information include a setup cost for each site, report generation costs per site or logger, and a user-defined other cost. In a similar

fashion to other costs, the user is allowed to also enter a supply cost. To use the section of the spreadsheet the user selects the labor and administrative categories, the labor and administrative hours associated with each task, and the number of times per year this task is performed. The spreadsheet then calculates the supply costs, labor costs, administrative costs and total costs associated with the reporting function.

54	Reporting													
55														
56	Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per yr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total	
57					Data Analyst		Project PI							
58			No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr		(=B×E)	(=C×E)	(=D×E)	(=F+G+H)	
59	Setup Costs		1	\$1.00	4		1		1	\$1	\$231	\$116	\$348	
60	Generation Costs		2	\$1.00	1	\$58	0.25	\$116	12	\$24	\$693	\$247	\$1,064	
61	other		2	\$0.00	0		0		0	\$0	\$0	\$0	\$0	
62														
63	Total Costs									\$25	\$324	\$462	\$1,411	

Figure 28: Utility.xls Workbook: Reporting

2.2.5.6 Utility.xls Workbook: Close-out, Data Transfer

The next section of the report involves costs associated with the close-out and data transfer tasks (see Figure 29). These tasks are often required when data from an M&V project are to be transferred to another job. The tasks assigned to the section of the spreadsheet include the close-out costs, data transfer costs, and other costs. Supply costs associated with these tasks can also be defined by the user. To use this section of the spreadsheet, the user enters the labor category, administrative category, labor and administrative hours associated with each task, and the number of times each task is to be performed. The spreadsheet then calculates the supply costs, labor, administrative costs and total costs.

65	Close-out, Data Transfer													
66														
67	Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per yr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total	
68					Data Analyst		Data Base Manager							
69			No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr		(=B×E)	(=C×E)	(=D×E)	(=F+G+H)	
70	Close-Out		1	\$1.00	2		1		1	\$1	\$116	\$58	\$174	
71	Data Transfer		1	\$1.00	2	\$58	1	\$58	2	\$2	\$231	\$116	\$349	
72	other		0	\$1.00	0		0		2	\$0	\$0	\$0	\$0	
73														
74	Total Costs									\$3	\$347	\$173	\$523	

Figure 29: Utility.xls Workbook: Close-out, Data Transfer

2.2.6 Utility.xls Workbook: Costing Information Input for Weather Data

Each of the previously mentioned workbooks (i.e., Project.xls and Utility.xls) will require some sort of weather data to be acquired either from the National Weather Service (NWS) or from another weather provider. In most instances there will be some sort of cost associated with the acquisition of weather data. To allow for this, the M&V Costing Toolkit has a costing information input for weather data. This section can be reached under the “Weather_Cost” tab of each workbook.

The user is then allowed to enter costing information that includes setup costs, polling/transfer costs, QC and database costs, data cleaning costs and other costs (see Figure 30). The user is also allowed to enter supply cost information for each function. After selecting the labor category and administration category, the user can then assign an hourly labor and administrative value to each task, as well as the number of times per year that the task is performed. The spreadsheet then calculates the total supply costs, labor costs, administration costs and total costs.

5	Hourly Weather Data												
6													
7	Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. NO. per yr	F. Total Price	G. Total Labor	H. Total Admin	I. Total
8			Data Base Support Worker		Project Engineer					(=B × E)	(=C × E)	(=D × E)	(=F+G+H)
9			No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
10	Setup Costs		1	\$1.00	2		0.25		1	\$1	\$81	\$14	\$96
11	Polling/Transfer		1	\$1.00	0.5		0.25		52	\$52	\$1,051	\$751	\$1,854
12	QC, Database Load		1	\$1.00	0.5	\$40	0.25	\$58	52	\$52	\$1,051	\$751	\$1,854
13	Data Cleaning		1	\$1.00	1		0.25		1	\$1	\$40	\$14	\$56
14	other		0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
15													
16	Total Costs									\$106	\$2,223	\$1,530	\$3,860

Figure 30: Utility.xls Workbook: Hourly Weather Data

2.2.7 Utility.xls Workbook: Cost Summary

In a similar fashion as the Project.xls, the Summary costs for the Utility.xls Workbook provides a summary of the costs from the previously entered data. It is also reached using the tabs at the bottom of the Utility.xls spreadsheet. In this section a summary of the costs is provided, which have previously been calculated in each of the previous sections as shown in Figure 31. In this section of the report the user only needs to update the Overhead and profits associated with the project, which are then applied to the summarized project costs.

Cost Summary	
1 Data transfer, QC and database Entry	\$4,642
2 Data Recovery/Missing Data	\$890
3 One Time Baseline/Post Retrofit Analysis	\$3,696
4 Ongoing Savings Analysis	\$2,796
5 Reporting	\$1,411
6 Close-out, Data Transfer	\$523
1 Hourly Weather Data	\$3,860
Overheads & Profits	22% \$3,920
Total Project Costs	\$21,737

Figure 31: Utility Workbook: Cost Summary

3. DESCRIPTION OF THE FILES CONTAINED ON THE DISTRIBUTION DISK.

There are seven files and 13 Scenario folders included with the distribution disk for the M&V Costing Toolkit. The first file “M&V Final Report.doc” is the file that contains this document. The Project.xls, Utility.xls, and the Fort Hood M&V Equipment Costs.xls files contain the M&V Toolkit. The remaining files are used for the sample M&V projects.

Below is the list of files contained on distribution disk.

- M&V Final Report.doc: The file containing this document.
- Project.xls: This is the Project.xls Workbook.
- Utility.xls: This is the Utility.xls Workbook.
- Fort Hood M&V Equipment Costs.xls: This is the database of all the M&V equipment and is linked to the Project_Cost spreadsheet of the Project.xls Workbook.
- Metering-Scenarios-for-CERL-MV.doc: This is a list of the thirteen metering scenarios for the CERL M&V Costing Toolkit.
- MeteringMatrix.xls: This file contains a table that lists the necessary M&V equipment for each of the thirteen metering scenarios.
- LaborCostMatrix.xls: This file contains a table that summarizes the labor costs for the thirteen metering scenarios.
- 13 Scenario Folders: Each of these folders contains a Project.xls workbook and a Fort Hood Equipment Costs.xls spreadsheet for a different metering scenario. There are thirteen folders total.
 - Lighting Scenario #1: Lighting retrofit
 - Lighting Scenario #2A: Lighting retrofit
 - Lighting Scenario #2B: Lighting retrofit
 - Lighting Scenario #3: Lighting retrofit
 - Chiller Scenario #1: Chiller retrofit
 - Chiller Scenario #2: Chiller retrofit
 - Chiller Scenario #3: Chiller retrofit
 - EMCS Scenario #1: EMCS retrofit
 - EMCS Scenario #2: EMCS retrofit
 - EMCS Scenario #3: EMCS retrofit
 - Boiler Scenario #1: Boiler retrofit
 - Boiler Scenario #2: Boiler retrofit
 - Boiler Scenario #3: Boiler retrofit

4. GENERAL INSTRUCTIONS FOR USE OF THE TOOLKIT

4.2. Installing files on distribution disk to your hard disk.

4.2.1. Creating a new folder

To begin the use of the M&V Costing Toolkit, it is recommended that a new folder be created for the storage of the generic files for the Toolkit, and one new folder for each job that the Toolkit is to be used on. For example, in the C drive, in the File menu, point to the New file, new Folder option, and then type “M&V-Toolkit” into the new folder name followed by the Enter key.

4.2.2. Copy files

To copy the files from the CD-ROM distribution diskette, after inserting the CD-ROM into the drive, open Windows Explorer, double click on the CD-ROM drive and open the drive. Select all Excel files on the CD-ROM. Then using the Edit menu, select Copy. Next, open the M&V-Toolkit folder, then on the Edit menu, select Paste. The three M&V Costing Toolkit files will then appear in the folder M&V-Toolkit. Next, since these files were copied from a CDROM, they need to have their read-only attribute changed. To do this, select all three files (i.e., using the Shift button together with the left mouse button). Then, using the right button on the mouse or keypad, select Properties, and then deselect the “read only” option (you can also deselect the Archive option).

4.2.3. Modifying the toolkit

Whenever you want to use the M&V Costing Toolkit you should change the Project.xls and Utility.xls file names and create new files for each project. To do this, open the folder that contains the M&V Toolkit. On the file menu point to the New file selection, then select a new folder, enter the new folder name. Then copy all three Excel files (i.e., the M&V Toolkit) into the new folder. Rename the Project.xls and Utility.xls file names to the appropriate name for this project, while leaving the Fort Hood Equipment Costs.xls file name alone. The Fort Hood Equipment Costs.xls file is linked to the Project.xls file, therefore if the name of the Fort Hood Equipment Costs.xls file is changed, the M&V Toolkit will not run.

4.2.4. Loading the M&V Costing Toolkit

You can load the M&V Costing Toolkit from Excel or directly using Explorer. In Figure 32 MS Excel has been started. In Excel, open all three files in the folder that contains the M&V Costing Toolkit. This can be done by pointing at all three files with the Shift and left button on the trackpad or mouse as shown in Figure 33, Figure 34, and Figure 35.

Once the three spreadsheets have been loaded, one of the spreadsheets can be selected for use by using the Window selection option. In Figure 36 the Project.xls Workbook has been selected. Figure 37 shows the relationship between each spreadsheet and the associated detailed costing information. In the next section, examples of each of the spreadsheets will be presented.

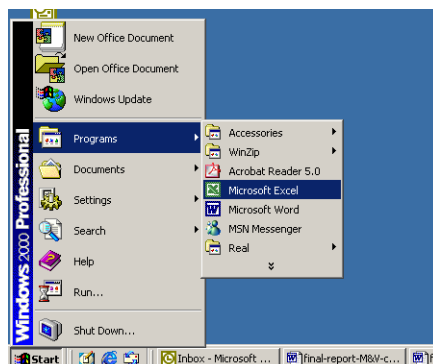


Figure 32: Run the Microsoft Excel Program

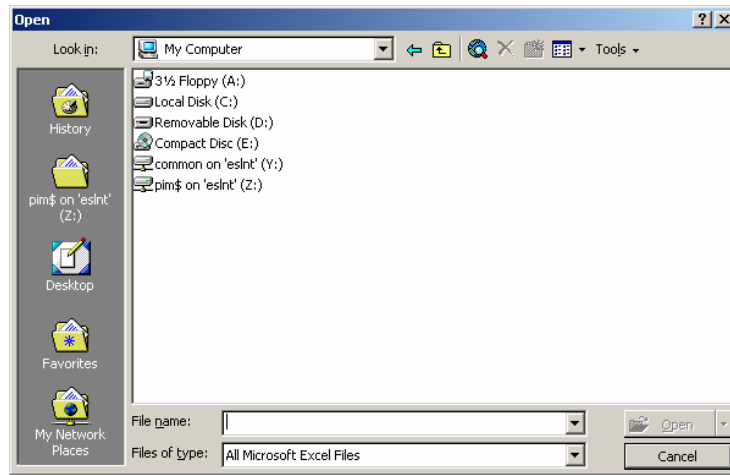


Figure 33: Open a dialog box

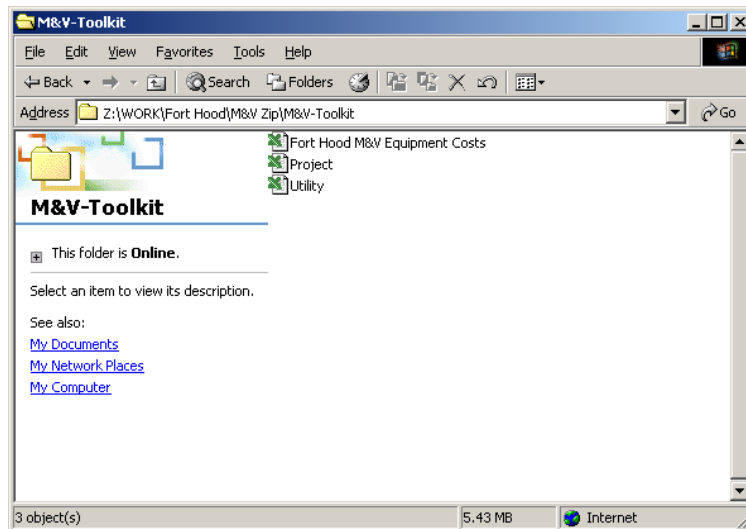


Figure 34: Browsing a folder to find the M&V Costing Toolkit workbooks.

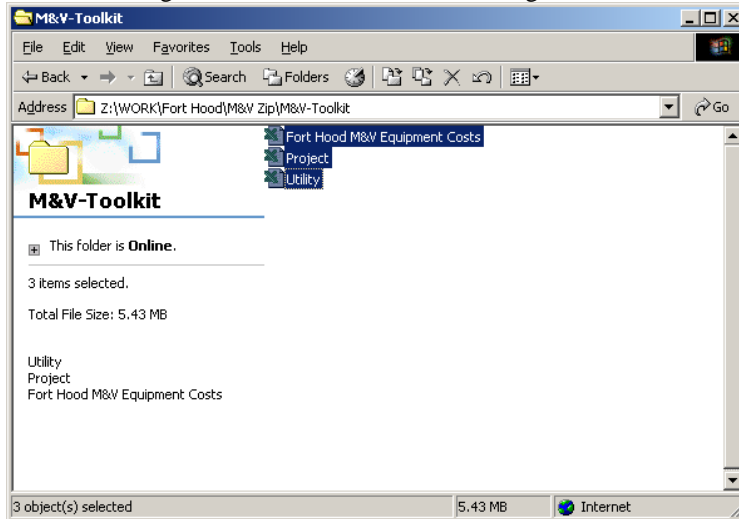


Figure 35: Select all files using Shift left button

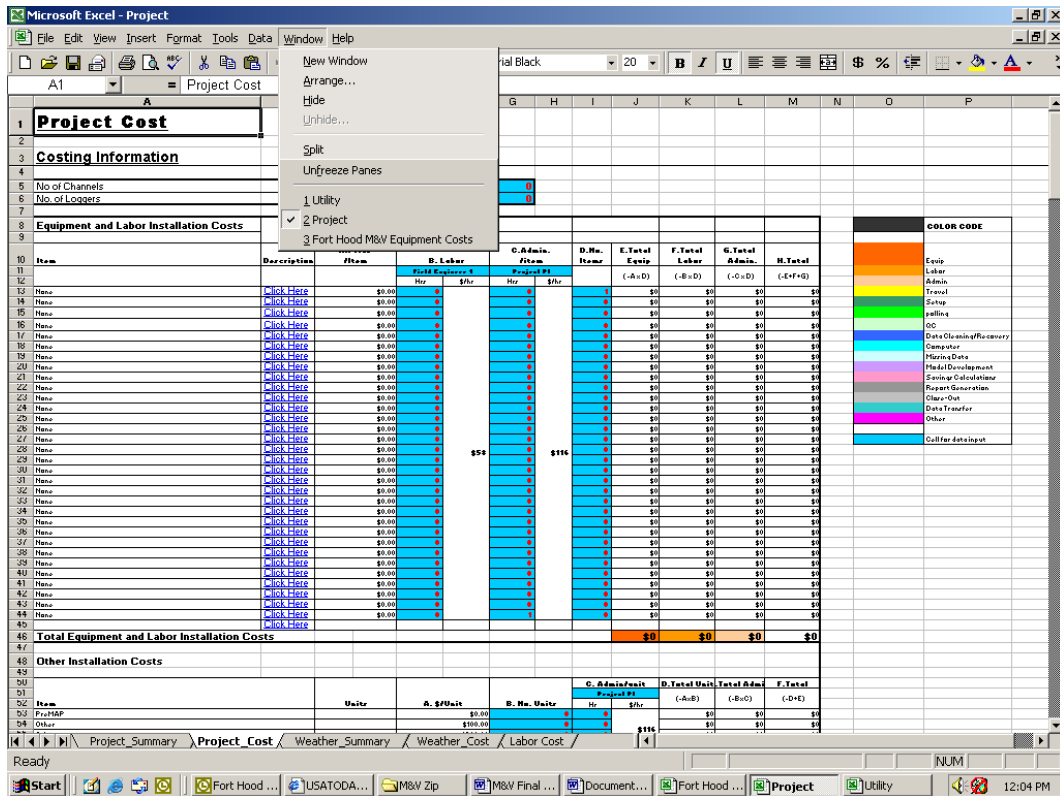


Figure 36: Select M&V Workbook from previously opened files.

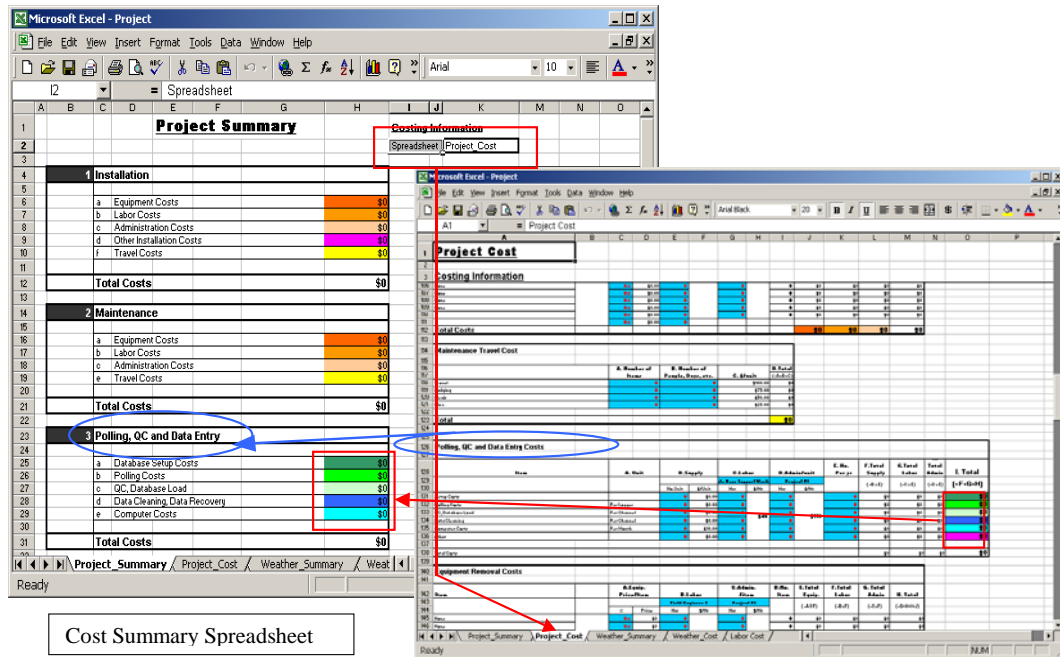


Figure 37: Relation between cost summary and costing information spreadsheet

5. EXAMPLE USE OF THE TOOLKIT

5.2. General Instruction

The general process for using the M&V Costing Toolkit is as follows:

- 1) First, choose a M&V Toolkit Workbook (either Project.xls or Utility.xls).
- 2) The next step is the input process. Most of the input cells are placed in the costing information spreadsheet. Therefore, when you want to input data, you should start from the costing spreadsheet. For the Project.xls Workbook, the costing spreadsheet is called 'Project_Cost' and for the Utility.xls Workbook, the costing spreadsheet is called 'Utility_Cost'.
- 3) After entering all of the required data, you can obtain the total cost from the cost summary spreadsheet. For the Project.xls Workbook, the cost summary spreadsheet is called 'Project_Summary' and for the Utility.xls Workbook, the cost summary spreadsheet is called 'Utility_Summary'.

Thirteen metering scenarios were developed to be used with the Project.xls Workbook of the M&V Costing Toolkit. This next section of the report discusses the use of the Project.xls Workbook with the thirteen scenarios, however only Lighting Scenario #1 will be discussed in detail. The thirteen metering scenarios are listed below:

- Lighting Scenario #1: Lighting retrofit – high cost, high accuracy (\$50,395)
- Lighting Scenario #2A: Lighting retrofit – medium-high cost, medium-high accuracy (\$27,215)
- Lighting Scenario #2B: Lighting retrofit - medium cost, medium accuracy (\$22,971)
- Lighting Scenario #3: Lighting retrofit – low cost, low accuracy (\$18,565)

- Chiller Scenario #1: Chiller retrofit – high cost, high accuracy (\$39,219)
- Chiller Scenario #2: Chiller retrofit - medium cost, medium accuracy (\$38,436)
- Chiller Scenario #3: Chiller retrofit – low cost, low accuracy (\$32,404)

- EMCS Scenario #1: EMCS retrofit – high cost, high accuracy (\$77,044)
- EMCS Scenario #2: EMCS retrofit - medium cost, medium accuracy (\$51,571)
- EMCS Scenario #3: EMCS retrofit – low cost, low accuracy (\$45,731)

- Boiler Scenario #1: Boiler retrofit – high cost, high accuracy (\$34,596)
- Boiler Scenario #2: Boiler retrofit - medium cost, medium accuracy (\$25,989)
- Boiler Scenario #3: Boiler retrofit – low cost, low accuracy (\$18,457)

In each of the sections that follow, the 13 scenarios are discussed, beginning with the general metering assumptions that were made for each scenario, followed by the detailed assumptions about the labor costs, and finally the summary costs for each scenario. Details about each scenario can be obtained by opening and inspecting the appropriate spreadsheet that accompanies this report.

5.3. Lighting Scenarios.

Four lighting scenarios were developed to illustrate the use of the M&V Costing Toolkit. The metering assumptions for these scenarios are shown in Figure 38, which include the functional type of data logger, electrical metering, thermal metering and equipment for measuring weather data. In this table the hours for the labor for installing the system are shown and the costs associated with the hours is shown in Figure 39.

5.3.1. Lighting Scenario #1: Lighting retrofit – high cost, high accuracy

In this section of the report detailed information is presented for the Lighting Scenario #1, which was developed to demonstrate a high cost, high accuracy metering project to validate lighting savings in a large building.

Savings to include:

- electricity savings from lighting retrofit normalized for occupancy
- cooling savings due to lighting retrofit normalized for weather
- additional heating gas use to make up for lighting retrofit normalized for weather
- chiller efficiency performance tracked
- boiler efficiency performance tracked

Analysis method:

- Daily electricity savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily lights and receptacle loads versus daily average NWS
- Hourly electric demand = 24 hour weather daytype profiles of lights and receptacle loads electricity using ASHRAE 1093 Toolkit on presorted data.
- Daily cooling savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE MCC electricity use versus daily average NWS
- Daily heating increase = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily whole-building gas use versus daily average NWS
- Hourly chiller performance model using ASHRAE 827 RP models
- Hourly boiler performance model

Metering:

- 15-minute whole-building electric using CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- 15-minute chiller Btu output using flow meter, temperature sensors and integrated Btu meter.
- 15-minute boiler Btu output using flow meter, temperature sensors and integrated Btu meter.
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses ASHRAE IMT, chiller models, boiler models, 1093 daytype profiles
- Electricity savings of lighting and receptacles normalized for weather and weekday/weekend.
- Separate electricity savings of cooling electricity use normalized for weather and weekday/weekend
- Natural gas take-back normalized for weather and weekday/weekend.

Cons:

- Weather dependent and weather independent savings combined into one model.
- Uses slightly more expensive DAS with integrated wattmeter
- More expensive, requires thermal metering, Btu meters.

Knowing the metering specifications, a table (located in Metering Matrix.xls) was then created that outlines what type of equipment would be needed in order to satisfy the metering requirements for the scenario. Figure 40 shows the portion of the Metering Matrix that deals with Lighting Scenario #1.

		LABOR HOURS	DATA LOGGERS	ELECTRICAL METERS	THERMAL METERS
		NUMBER OF CHANNELS	1		
Lighting Scenario #1: Lighting Retrofit: High Cost/High Accuracy					
1.	Plumber Building Electrical MDP Bus Bar - Log 15 min. data	Plumbing Contractor	00	X	X
1a.	Logger calculate Power Consumption	Electrical Contractor	00		
2.	Schedule MDP in MDP - Log 15 min. data	Trin of Programming Technicians	00		
2a.	Logger calculate Power Consumption	Technicians to verify installation	40	X	
3.	Logger calculate HW Energy consumption - 15 min. data	Manager/Project Engineer	20		
3a.	Inlet/Flow meter and temperature sensor	Equipment Removal	20		X
4.	Logger calculate HW Energy consumption - Log 15 min. data	ProMAP	30		X
4a.	Inlet/Flow meter and temperature sensor				X
5.	Duplicate Gas Utility Meter Pulse - Log 15 min. data				X
6.	Hourly Weather data from NWS				

Figure 40: Metering Matrix for Lighting Scenario #1

5.3.1.1. Lighting Scenario #1: Labor Costs

The next step involves setting the hourly labor rate for Lighting Scenario #1. In the M&V Costing Toolkit, the user has the ability to set the hourly labor costs using the Labor Costing Information tab. This tab is located at the bottom of spreadsheet and is labeled ‘Labor Cost’. Figure 41 shows this section of the Project.xls workbook. For most projects the user will need to update the hourly billing rates for the different personnel on the project. The total hourly rate is then calculated as 115.5% of the hourly rate for each employee. The 15.5% can also be changed by the user by changing the formula for Fringe Benefit.

Labor Cost Information				
Personnel	Rate (\$/Hr)	Fringe Benefit (15.5% of Rate)	Total	
Project PI	\$100	\$16	\$116	
Project CoPI	\$100	\$16	\$116	
Project Manager I	\$75	\$12	\$87	
Project Engineer	\$50	\$8	\$58	
Data Base Support Worker	\$35	\$5	\$40	
Data Base Manager	\$50	\$8	\$58	
Programming Manager	\$75	\$12	\$87	
Field Engineer 1	\$50	\$8	\$58	
Field Engineer 2	\$35	\$5	\$40	
Data Base Programmer	\$35	\$5	\$40	
Data Analyst	\$50	\$8	\$58	
Total			\$757	

Figure 41: Project.xls Workbook: Lighting Scenario #1: Labor Cost Information

5.3.1.2. Lighting Scenario #1: No. of Channels & No. of Loggers

For the Lighting Scenario #1 (13) channels were to be used to record the data from the retrofit. These channels were to be collected by (1) data logger as shown in Figure 42.

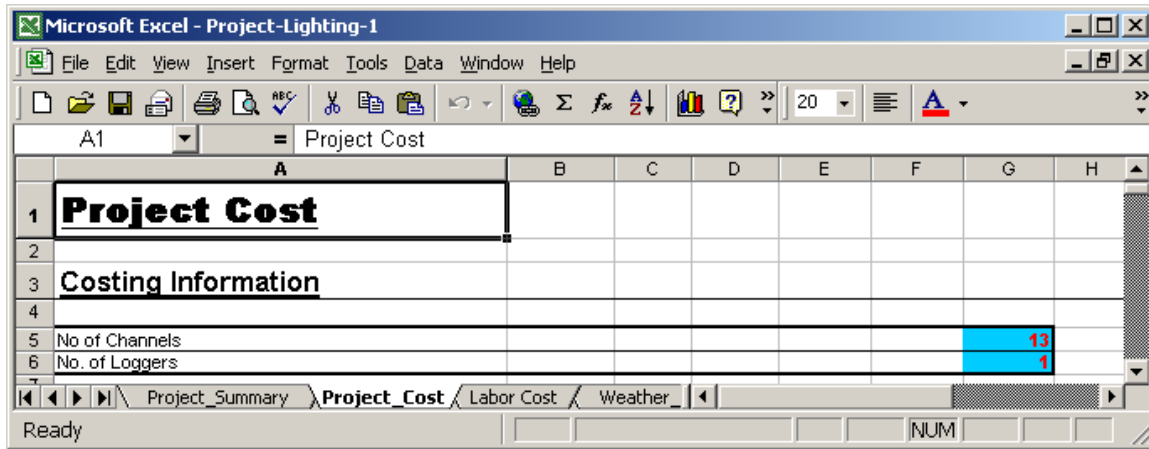


Figure 42: Project.xls Workbook: Lighting Scenario #1: No. of Channels and Loggers

5.3.1.3. Lighting Scenario #1: Equipment and Labor Installation Costs

The first category to appear at the top of the Costing input sheet in Lighting Scenario #1 is for the installation of the Data Loggers, including the Equipment and Labor Installation Costs shown in Figure 43, with details provided in Figure 39. In this scenario, \$19,923 are estimated for installation labor costs¹, and about \$5,982 for equipment costs.

Equipment and Labor Installation Costs												
Item	Description	A.Price /Item	B. Labor		C.Admin. /Item		D.No. Items	E.Total Equip (=A x D)	F.Total Labor (=B x D)	G.Total Admin. (=C x D)	H.Total (=E+F+G)	
			Programming Manager Hrs	\$/hr	Project Pl Hrs	\$/hr						
13	Logger(ENERNET Corporation, K20-2)	\$2,490.00	0	0	0	0	1	\$2,490	\$0	\$0	\$2,490	
14	Potential Transducer(Sentran Corp., VTx)	\$75.00	0	0	0	0	1	\$75	\$0	\$0	\$75	
15	Current Transducer(Sentran Corp., 4LS Series)	\$72.00	0	0	0	0	6	\$432	\$0	\$0	\$432	
16	Flowmeter(Onicon, Inc., F-110)	\$934.00	0	0	0	0	2	\$1,868	\$0	\$0	\$1,868	
17	RTD Temp Sensor(Kele Solutions, ST-W85)	\$165.73	0	0	0	0	4	\$663	\$0	\$0	\$663	
18	Signal Transmitter(Kele Solutions, Model DT13)	\$217.78	0	0	0	0	1	\$218	\$0	\$0	\$218	
19	Misc.(Sprint, F311)	\$110.60	0	0	0	0	1	\$111	\$0	\$0	\$111	
20	Misc.(Kele Solutions, Model 631-U100)	\$87.78	0	0	0	0	1	\$88	\$0	\$0	\$88	
21	Misc.(Conduit, 1/2" Conduit Cost/Hr)	\$0.38	0	0	0	0	100	\$38	\$0	\$0	\$38	
22	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
23	None	\$0.00	229	0	0	0	1	\$0	\$19,923	\$0	\$19,923	
24	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
25	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
26	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
27	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
28	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
29	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
30	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
31	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
32	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
33	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
34	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
35	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
36	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
37	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
38	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
39	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
40	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
41	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
42	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
43	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
44	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
45	None	\$0.00	0	0	0	0	0	\$0	\$0	\$0	\$0	
46	Total Equipment and Labor Installation Costs								\$5,982	\$19,923	\$0	\$25,905

Figure 43: Project.xls Workbook: Lighting Scenario #1: Equipment and Labor installation Costs

¹ The \$19,923 value is an estimate of the detailed labor cost of \$20,000.

5.3.1.4. Lighting Scenario #1: Other Installation Costs

In most installations there will also be other costs associated with the installation that include such tasks as the development of Preliminary Monitoring Analysis Plans (PreMAPs), the ordering of parts, etc. These costs can be accounted for using the Other Installation costs. In Scenario #1 (30) hours is estimated for the PreMAP.

Item	Units	A. \$/Unit	B. No. Units	C. Admin/unit		D.Total Unit (=A*B)	Total Admin (=B*C)	F.Total (=D+E)
				Project #1 Hr	\$/hr			
PreMAP		\$0.00	1	30		\$0	\$3,480	\$3,480
Other		\$100.00	0	0	\$116	\$0	\$0	\$0
Other		\$200.00	0	0		\$0	\$0	\$0
Other		\$0.00	0	0		\$0	\$0	\$0
Total Other Installation Costs						\$0	\$3,480	\$3,480
Total Installation Costs								\$29,385

Figure 44: Project.xls Workbook: Lighting Scenario #1: Other Installation Costs.

5.3.1.5. Lighting Scenario #1: Installation Travel Costs

For those sites located some distance from the M&V provider, there will be travel costs associated with site visits. These can be accounted for in several areas of the Costing Input Spreadsheet. In Figure 45 the travel costs for Scenario #1 are estimated to contain 2 days of transportation costs at \$50/day for the rental car, and one overnight for \$100/night, with meals estimated to be three meals for two days equal to six meals at \$10 per meal. Total installation travel costs for the Project Engineer are estimated at \$260. Travel costs for the subcontractors are assumed to be included in their hourly rates.

	A. Number of Items	B. Number of People, Days, etc.	C. \$/unit	D.Total (=A*B*C)
Transportation	2	1	\$50.00	\$100
Lodging days	1	1	\$100.00	\$100
Meals per day	6	1	\$10.00	\$60
Misc.	0	0	\$0.00	\$0
Total				\$260

Figure 45: Project.xls Workbook: Lighting Scenario #1: Installation Travel Costs

5.3.1.6. Lighting Scenario #1: Maintenance and Labor Costs per Year

Maintenance and the associated labor costs for the job are shown in Figure 46. These maintenance costs are tied to the installation costs and are calculated as a percent (%) of the price of the original item plus the labor associated with the device during the maintenance trip. In Scenario #1 these are estimated to be significant costs for the logger, flowmeters, temperature sensors, and signal transducers, which total \$1,791 during the maintenance period.

Item	A.Price /Item		B.Labor		C.Admin. /Item		D.No. Items	E.Total Equip. (=A×D)	F.Total Labor (=B×D)	G.Total Admin. (=C×D)	H.Total (=E+F+G)
	%	Price	Hrs	\$/Hr	Hrs	\$/Hr					
78 Logger(ENERNET Corporation, K20-2)	5%	\$124.50	0		4		1	\$125	\$0	\$464	\$589
79 Potential Transducer(Sentran Corp., VTX)	0%	\$0.00	0		0		1	\$0	\$0	\$0	\$0
80 Current Transducer(Sentran Corp., 4LS Series)	0%	\$0.00	0		0		6	\$0	\$0	\$0	\$0
81 Flowmeter(Onicon, Inc., F-110)	10%	\$33.40	0		0		2	\$187	\$328	\$0	\$115
82 RTD Temp Sensor(Kele Solutions, ST-V85)	10%	\$18.57	0		0		4	\$66	\$0	\$0	\$66
83 Signal Transmitter(Kele Solutions, Model DT13)	10%	\$21.73	0		0		1	\$22	\$0	\$0	\$22
84 Misc.(Sprint, RJ11)	0%	\$0.00	0		0		1	\$0	\$0	\$0	\$0
85 Misc.(Kele Solutions, Model 691-U100)	0%	\$0.00	0		0		1	\$0	\$0	\$0	\$0
86 Misc.(Conduit, 10" Conduit Cost/R)	0%	\$0.00	0		0		100	\$0	\$0	\$0	\$0
87 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
88 None	0%	\$0.00	0		0		1	\$0	\$0	\$0	\$0
89 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
90 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
91 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
92 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
93 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
94 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
95 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
96 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
97 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
98 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
99 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
100 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
101 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
102 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
103 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
104 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
105 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
106 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
107 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
108 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
109 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
110 None	0%	\$0.00	0		0		0	\$0	\$0	\$0	\$0
111 Total Costs	0%	\$0.00	0		0		0	\$399	\$928	\$464	\$1,791

Figure 46: Project.xls Workbook: Lighting Scenario #1: Maintenance and Labor Costs Per Year

5.3.1.7. Lighting Scenario #1: Maintenance Travel Costs

The travel costs associated with maintenance are shown in Figure 47, and include 2 days of transportation costs (i.e., rental car), one day of lodging for one person, and six meals for one person over two days, for a total cost of \$260.

	A. Number of Items	B. Number of People, Days, etc.	C. \$/unit	D. Total (=AxBxC)
118 Travel	2	1	\$50.00	\$100
119 Lodging	1	1	\$100.00	\$100
120 Meals	6	1	\$10.00	\$60
121 Misc.	0	0	\$0.00	\$0
Total				\$260

Figure 47: Project.xls Workbook: Lighting Scenario #1: Maintenance Travel Costs

5.3.1.8. Lighting Scenario #1: Polling, QC and Data Entry Costs

The polling, QC and Data Entry costs are shown in Figure 48. These costs include: a one-time setup cost for 13 channels, 52 weeks of polling costs for one logger, 52 weeks of QC, and database loading, a one-time cost for data cleaning, 12 months of computer maintenance, for a total cost of \$1,361.

Item	A. Unit	B. Supply		C. Labor		D. Admin/Unit	E. No. Per yr	F. Total Supply (-D x E)	G. Total Labor (-D x E)	H. Total Admin (-D x E)	I. Total (=F+G+H)
		No/Unit	\$/Unit	Wks	\$/Wk						
131 Setup Cost		13	\$0.00	1	\$0	\$0	1	\$0	\$40	\$0	\$40
132 Polling Cost	Per Logger	1	\$0.00	52	\$0.01	\$0.52	52	\$0	\$520	\$0	\$520
133 QC, Database Load	Per Channel	13	\$0.00	52	\$0.01	\$0.68	52	\$0	\$208	\$0	\$208
134 Data Cleaning	Per Channel	13	\$0.00	1	\$0.01	\$0.13	1	\$0	\$40	\$0	\$40
135 Computer Cost	Per Month	12	\$10.00	0	\$0	\$0	12	\$120	\$0	\$0	\$120
136 Long Distance Phone Charge	Per Month	1	\$25.00	0	\$0	\$0	12	\$300	\$0	\$0	\$300
137 Total Cost								\$420	\$100	\$103	\$1,361

Figure 48: Project.xls Workbook: Lighting Scenario #1: Polling, QC and Data Entry Costs

5.3.1.9. Lighting Scenario #1: Equipment Removal Costs

The equipment removal costs are shown in Figure 49. In a similar fashion to the maintenance costs, these costs are expressed as a percent (%) of the original equipment cost. These costs are estimated to be \$916 for the removal of the data logger, and the connected sensors, etc.

5.3.1.11. Lighting Scenario #1: Data Recovery/Missing Data

Quite often during the course of a metering and verification project there will be periods of missing data or data that needs to be rescaled. In Figure 51 the data entry section of the spreadsheet for data recovery/missing data is shown. In the example shown, these costs are estimated to be \$302.

Item	A. Unit	B. Supply		C. Labor		D. Admin/Facit		E. No. Unit	F. Total Supply (-B x E)	G. Total Labor (-C x E)	H. Total Admin (-D x E)	I. Total (=F+G+H)
		No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
Data Recovery	Per Channel	15	\$1.00	2	\$50	1	\$114	1	\$15	\$20	\$55	\$151
Missing Data	Per Channel	15	\$1.00	2	\$50	1	\$114	1	\$15	\$20	\$55	\$151
Labor		8	\$0.00	8		8		8	\$0	\$0	\$0	\$0
Total Cost									\$24	\$160	\$118	\$302

Figure 51: Project.xls Workbook: Lighting Scenario #1: Data Recovery/Missing Data

5.3.1.12. Lighting Scenario #1: One Time Baseline/Post Retrofit Analysis

In most monitoring and verifications projects there will be a need to developing a baseline model, which is needed to project the pre-retrofit energy use into the post-retrofit period. Often, when there are missing data there is also a need to develop a post-retrofit model to fill-in missing data that might occur during the post-retrofit period. To account for the costs of this Figure 52 shows the cost information entry section of the spreadsheet for determining the costs associated with one time baseline or post retrofit models. In the example shown these costs are estimated to be \$766.

Item	A. Unit	B. Supply		C. Labor		D. Admin/Facit		E. No. Unit	F. Total Supply (-B x E)	G. Total Labor (-C x E)	H. Total Admin (-D x E)	I. Total (=F+G+H)
		No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
Setup Cost		4	\$0.00	4		4		4	\$0	\$222	\$12	\$244
Model Development Cost	Model	1	\$0.00	1	\$54	1	\$114	1	\$0	\$444	\$58	\$522
Evening Calculations		4	\$0.00	4		4		4	\$0	\$0	\$0	\$0
Total Cost									\$0	\$666	\$170	\$766

Figure 52: Project.xls Workbook: Lighting Scenario #1: One Time Baseline/Post Retrofit Analysis

5.3.1.13. Lighting Scenario #1: Ongoing Savings Analysis

After the baseline and/or post-retrofit models are created, the coefficients from the models will need to be applied to the data that are being collected in the post-retrofit period. To account for these costs Figure 53 shows the ongoing savings analysis costs. For this example, these costs are estimated to be \$1,033.

The screenshot shows the 'Project Cost' workbook with the 'Ongoing Savings Analysis' table. The table has columns for Item, A. Unit, B. Supply, C. Labor, D. Admin/Unit, E. No. Per yr, F. Total Supply, G. Total Labor, H. Total Admin, and I. Total. The data rows are:

Item	A. Unit	B. Supply		C. Labor		D. Admin/Unit		E. No. Per yr	F. Total Supply (=B×E)	G. Total Labor (=C×E)	H. Total Admin (=D×E)	I. Total (=F+G+H)
		No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
Medical Development Costs		1	\$1.00	0.25		0.1		12	\$12	\$174	\$70	\$256
Savings Calculations		1	\$1.00	1	\$58	0.1	\$58	12	\$12	\$696	\$70	\$778
Other		0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
Total Costs									\$24	\$970	\$139	\$1,033

Figure 53: Project.xls Workbook: Lighting Scenario #1: Ongoing Savings Analysis

5.3.1.14. Lighting Scenario #1: Creating the Basic Simulation Input File

In the Lighting Scenario #1 this option was not used, therefore all values were set equal to zero as shown in Figure 54.

The screenshot shows the 'Project Cost' workbook with the 'Creating the Basic Simulation Input File' table. The table has columns for Item, A. Unit, B. Supply, C. Labor, D. Admin/Unit, E. No. Per yr, F. Total Supply, G. Total Labor, H. Total Admin, and I. Total. The data rows are:

Item	A. Unit	B. Supply		C. Labor		D. Admin/Unit		E. No. Per yr	F. Total Supply (=B×E)	G. Total Labor (=C×E)	H. Total Admin (=D×E)	I. Total (=F+G+H)
		No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
Overhead LOADS	Files	0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
Overhead SYSTEMS	Files	0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
Overhead PLANT	Files	0	\$0.00	0	\$58	0	\$116	0	\$0	\$0	\$0	\$0
Overhead ECONOMICS	Files	0		0		0		0	\$0	\$0	\$0	\$0
Other		0		0		0		0	\$0	\$0	\$0	\$0
Total Costs									\$0	\$0	\$0	\$0

Figure 54: Project.xls Workbook: Lighting Scenario #1: Creating the Basic Simulation Input File

5.3.1.15. Lighting Scenario #1: Calibrating the Simulation

In the Lighting Scenario #1 this option was not used, therefore all values were set equal to zero as shown in Figure 55.

Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per yr	F. Total Supply (-B x E)	G. Total Labor (-C x E)	H. Total Admin (-D x E)	I. Total (=F+G+H)
		No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
243	Calib. LOADS Dimensions	Procedure	\$0.00					0	\$0	\$0	\$0	\$0
244	Calib. LOADS Schedules	Procedure	\$0.00					0	\$0	\$0	\$0	\$0
245	Calib. LOADS Int.Env.Cond.	Procedure	\$0.00					0	\$0	\$0	\$0	\$0
246	Packing Weather Tape	Procedure	\$10.00		\$58		\$116	0	\$0	\$0	\$0	\$0
247	Calib SYSTEMS	Procedure	\$0.00					0	\$0	\$0	\$0	\$0
248	Calib PLANT	Procedure	\$0.00					0	\$0	\$0	\$0	\$0
249	Other							0	\$0	\$0	\$0	\$0
250	Total Cost								\$0	\$0	\$0	\$0

Figure 55: Project.xls Workbook: Lighting Scenario #1: Calibrating the Simulation

5.3.1.16. Lighting Scenario #1: Use the Calibrated Simulation to Calculate Baseline

In the Lighting Scenario #1 this option was not used, therefore all values were set equal to zero as shown in Figure 56.

Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. No. Per yr	F. Total Supply (-B x E)	G. Total Labor (-C x E)	H. Total Admin (-D x E)	I. Total (=F+G+H)
		No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
258	Setup Cost		\$0.00					0	\$0	\$0	\$0	\$0
259	Model Development Cost		\$0.00					0	\$0	\$0	\$0	\$0
260	Calculate Baseline		\$0.00					0	\$0	\$0	\$0	\$0
261	Other		\$0.00					0	\$0	\$0	\$0	\$0
262												
263	Total Cost								\$0	\$0	\$0	\$0

Figure 56: Project.xls Workbook: Lighting Scenario #1: Use the Calibrated Simulation to Calculate Baseline

5.3.1.17. Lighting Scenario #1: Use the Calibrated Simulation to Calculate Ongoing Savings

In the Lighting Scenario #1 this option was not used, therefore all values were set equal to zero as shown in Figure 57.

Item	A. Unit	B. Supply		C. Labor		D. Admin/Unit		E. No. Per yr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
		No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
Model Development Costs		1	\$1.00	1		1		1	\$1	\$0	\$0	\$0
Savings Calculations		1	\$1.00	1	\$54	1	\$54	1	\$0	\$0	\$0	\$0
other		1	\$0.00	1		1		1	\$0	\$0	\$0	\$0
Total Costs									\$1	\$0	\$0	\$1

Figure 57: Project.xls Workbook: Lighting Scenario #1: Use the Calibrated Simulation to Calculate Ongoing Savings

5.3.1.18. Lighting Scenario #1: Reporting

In the Lighting Scenario #1 this option included \$1,301 in costs for setup, and report generation costs as shown in Figure 58.

Item	A. Unit	B. Supply		C. Labor		D. Admin/Unit		E. No. Per yr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
		No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
Setup Costs		1	\$1.00	1		1		1	\$1	\$232	\$12	\$245
Generation Costs		1	\$1.00	1	\$54	1	\$116	1	\$1	\$12	\$164	\$181
other		1	\$0.00	1		1		1	\$0	\$0	\$0	\$0
Total Costs									\$2	\$244	\$176	\$1,301

Figure 58: Project.xls Workbook: Lighting Scenario #1: Reporting

5.3.1.19. Lighting Scenario #1: Close-out, Data Transfer

In the Lighting Scenario #1 this option included \$130 in costs for close-out and data transfer as shown in Figure 60.

Item	A. Unit	B. Supply		C. Labor		D. Admin/Unit		E. No. Per yr	F. Total Supply	G. Total Labor	H. Total Admin	I. Total
		No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
Close-Out		1	\$1.00	1		1		1	\$1	\$50	\$1	\$52
Data Transfer		1	\$1.00	1	\$54	1	\$54	1	\$1	\$50	\$1	\$56
other		1	\$1.00	1		1		1	\$0	\$0	\$0	\$0
Total Costs									\$2	\$101	\$12	\$130

Figure 59: Project.xls Workbook: Lighting Scenario #1: Close-out, Data Transfer

5.3.1.20. Lighting Scenario #1: Hourly Weather Data

In the Lighting Scenario #1 this option included \$3,843 in costs for setup, polling and transfer, QC, Database loading, and data cleaning as shown in Figure 60.

Item	A. Unit	B. Supply		C. Labor		D. Admin/unit		E. NO. per yr	F. Total Price (=B×E)	G. Total Labor (=C×E)	H. Total Admin (=D×E)	I. Total (=F+G+H)
		No. Unit	\$/Unit	Hrs	\$/Hr	Hrs	\$/Hr					
Setup Costs		1	\$1.00	2		0.25		1	\$1	\$80	\$15	\$96
Polling/Transfer		1	\$1.00	0.5		0.25		52	\$52	\$1,040	\$754	\$1,846
QC, Database Load		1	\$1.00	0.5	\$40	0.25	\$58	52	\$52	\$1,040	\$754	\$1,846
Data Cleaning		1	\$1.00	1		0.25		1	\$1	\$40	\$15	\$56
other		0	\$0.00	0		0		0	\$0	\$0	\$0	\$0
Total Costs									\$106	\$2,200	\$1,537	\$3,843

Figure 60: Project.xls Workbook: Lighting Scenario #1: Hourly Weather Data

5.3.1.21. Lighting Scenario #1: Cost Summary

Once the detailed cost information has been entered into the cost information spreadsheet, the user then transfers back to the Data Logger summary sheet to view the summary of all costs associated with the project. Figure 61 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$50,395.

Cost Summary		
Project	1 Installation	\$29,645
	2 Maintenance	\$2,051
	3 Polling, QC and Data Entry	\$1,061
	4 Equipment Removal	\$1,176
	5 Data Recovery/Missing Data	\$302
	6 One Time Baseline/Post Retrofit Analysis	\$766
	7 Ongoing Savings Analysis	\$1,033
	8 Creating the Basic simulation Input File	\$0
	9 Calibrating Simulation	\$0
	10 Use the Calibrated Simulation to Caculate Baseline	\$0
	11 Use the Calibrated Simulation to Caculate Ongoing	\$0
	12 Reporting	\$1,301
	13 Close-out, Data Transfer	\$130
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$9,088
Total Project Costs		\$50,395

Figure 61: Project.xls Workbook: Lighting Scenario #1: Cost Summary

5.3.2. Lighting Scenario #2A: Lighting retrofit – medium-high cost, medium-high accuracy

In this section of the report detailed information is presented for the Lighting Scenario #2A, which was developed to demonstrate a medium-high cost, medium-high accuracy metering project to validate lighting savings in a large building.

Savings to include:

- electricity from lighting retrofit normalized for occupancy
- cooling savings due to lighting retrofit normalized for weather
- additional heating gas to make up for lighting retrofit normalized for weather

Analysis method:

- Daily electricity savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily lights and receptacle loads versus daily average NWS
- Hourly electric demand = 24 hour weather daytype profiles of lights and receptacle loads electricity using ASHRAE 1093 Toolkit on presorted data.
- Daily cooling electricity savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE MCC electricity use versus daily average NWS
- Daily natural gas increase = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily whole-building gas use versus daily average NWS

Metering:

- 15-minute whole-building electric using CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Simple to install.
- Uses CTs, PTs and integrated wattmeters
- Uses closest NWS
- Analysis relatively simple, uses ASHRAE IMT and daytype profiles
- Electricity savings of lighting and receptacles normalized for weather and weekday/weekend.
- Separate electricity savings of cooling electricity use normalized for weather and weekday/weekend
- Natural gas take-back normalized for weather and weekday/weekend.

Cons:

- Weather dependent and weather independent savings combined into one model.
- Uses slightly more expensive DAS with integrated wattmeter
- Not normalized for:
 - Changes in chiller efficiency or operation
 - Changes in boiler efficiency or operation

5.3.2.1. Lighting Scenario #2A: Cost Summary

Figure 62 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$27,215.

Cost Summary		
Project	1 Installation	\$11,982
	2 Maintenance	\$870
	3 Polling, QC and Data Entry	\$1,126
	4 Equipment Removal	\$1,176
	5 Data Recovery/Missing Data	\$290
	6 One Time Baseline/Post Retrofit Analysis	\$766
	7 Ongoing Savings Analysis	\$1,033
	8 Creating the Basic simulation Input File	\$0
	9 Calibrating Simulation	\$0
	10 Use the Calibrated Simulation to Caculate Baseline	\$0
	11 Use the Calibrated Simulation to Caculate Ongoing	\$0
	12 Reporting	\$1,092
	13 Close-out, Data Transfer	\$130
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$4,908
Total Project Costs		\$27,215

Figure 62: Project.xls Workbook: Lighting Scenario #2a Cost Summary

5.3.3. Lighting Scenario #2B: Lighting retrofit - medium cost, medium accuracy

In this section of the report detailed information is presented for the Lighting Scenario #2B, which was developed to demonstrate a medium cost, medium accuracy metering project to validate lighting savings in a large building.

Savings to include:

- electricity from combined lighting retrofit, and cooling savings due to lighting retrofit normalized for weather
- additional natural gas to make up for lighting retrofit normalized for weather
- electricity from lighting retrofit normalized for occupancy

Analysis method:

- Daily electricity savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily whole-building electricity versus daily average NWS
- Hourly electric demand = 24 hour weather daytype profiles of whole-building electricity using ASHRAE 1093 Toolkit on presorted data.
- Daily natural gas increase = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily whole-building gas use versus daily average NWS

Metering:

- 15-minute whole building electric using pulse from main meter
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- digital DAS
- hourly weather data from NWS

Pros:

- Simple to install.
- Uses digital pulse from existing meters
- Uses inexpensive digital DAS
- Uses closest NWS
- Analysis relatively simple, uses ASHRAE IMT
- Electricity savings normalized for weather and weekday/weekend.
- Natural gas take-back normalized for weather and weekday/weekend.

Cons:

- Weather dependent and weather independent savings combined into one model.
- Not normalized for:
 - Changes in chiller efficiency or operation
 - Changes in boiler efficiency or operation
 - Changes in occupancy patterns
 - Lamp burn-outs, replacements

5.3.3.1. Lighting Scenario #2B: Cost Summary

Figure 63 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$22,971.

Cost Summary		
Project	1 Installation	\$9,620
	2 Maintenance	\$908
	3 Polling, QC and Data Entry	\$1,061
	4 Equipment Removal	\$776
	5 Data Recovery/Missing Data	\$280
	6 One Time Baseline/Post Retrofit Analysis	\$371
	7 Ongoing Savings Analysis	\$799
	8 Creating the Basic simulation Input File	\$0
	9 Calibrating Simulation	\$0
	10 Use the Calibrated Simulation to Caculate Baseline	\$0
	11 Use the Calibrated Simulation to Caculate Ongoing	\$0
	12 Reporting	\$976
	13 Close-out, Data Transfer	\$194
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$4,142
Total Project Costs		\$22,971

Figure 63: Project.xls Workbook: Lighting Scenario #2B Cost Summary

5.3.4. Lighting Scenario #3: Lighting retrofit – low cost, low accuracy

In this section of the report detailed information is presented for the Lighting Scenario #2B, which was developed to demonstrate a low cost, low accuracy metering project to validate lighting savings in a large building.

Savings to include:

- electricity from combined lighting retrofit, and cooling savings due to lighting retrofit normalized for weather
- additional natural gas to make up for lighting retrofit normalized for weather

Analysis method:

- Monthly electricity savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of monthly whole-building electricity versus average NWS for the billing period
- Monthly electric demand = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of monthly whole-building electric demand versus max temperatures from NWS for the billing period

- Cross-check of lighting savings = combination of blink test of before/after loads to confirm calculations of peak lighting load reductions and usage profiles from lighting loggers
- Monthly natural gas increase = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of monthly whole-building gas use versus average NWS for the billing period

Metering:

- Monthly utility bills for electricity use and electric demand
- Monthly utility bills for natural gas
- 5-minute whole building electric using portable meter
- hourly weather data from NWS
- 1 month of lighting loggers to confirm lighting use profiles before and after lighting retrofits

Pros:

- Simple to install, requires one weekend before/after retrofit for blink tests.
- Uses digital pulse from existing electricity meter
- Uses inexpensive portable digital DAS
- Uses closest NWS
- Analysis relatively simple, uses ASHRAE IMT, 1093 toolkit and blink test data
- Electricity savings normalized for monthly weather
- Natural gas take-back normalized for monthly weather
- Can detect changes in occupancy patterns using lighting loggers
- Can detect changes in large numbers of lamp burn-outs, replacements using blink test.

Cons:

- Weather dependent and weather independent savings combined into one monthly model.
- Requires placing and retrieving lighting loggers.
- Requires blink test to be run before/after lighting retrofit
- Not normalized for:
 - Changes in chiller efficiency or operation
 - Changes in boiler efficiency or operation

5.3.4.1. Lighting Scenario #2B: Cost Summary

Figure 64 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$18,565.

		LABOR HOURS			
		Metering Installation Labor in Hours (does not include engineering analysis)			
				Labor Cost per Hour	Total Cost per Labor Category
Chiller Scenario #1: Chiller Retrofit: high Cost/ high Accuracy					
1.	Meter Building Electrical MDP Bus Bars - Log 15 min. data	Electrical Contractor:	40	\$75.00	\$3,000.00
1a.	Logger calculates Power Consumption	Wiring/Programming Technician:	40	\$50.00	\$2,000.00
2.	Submeter MCC at MDP - Log 15 min. data	Technician to verify installation:	40	\$50.00	\$2,000.00
2a.	Logger calculates Power Consumption	Manager/Project Engineer:	20	\$100.00	\$2,000.00
3.	Logger calculates CHW Energy consumption -15 min. data	Plumbing Contractor :	40	\$75.00	\$3,000.00
3a.	Install flow meters and temperature sensors	PreMAP	40	\$116.00	\$4,640.00
4.	Measure chiller's condenser water temperature	Equipment Removal:	20	\$40.00	\$800.00
5.	Hourly Weather data from NWS	Total Cost			\$12,000.00
Chiller Scenario #2: Chiller Retrofit: med. Cost/ med. Accuracy					
1.	Meter Building Electrical MDP Bus Bars - Log 15 min. data	Electrical Contractor:	20	\$75.00	\$1,500.00
1a.	Logger calculates Power Consumption	Wiring/Programming Technician:	40	\$50.00	\$2,000.00
2.	Logger calculates CHW Energy consumption -15 min. data	Technician to verify installation:	40	\$50.00	\$2,000.00
2a.	Install flow meters and temperature sensors	Manager/Project Engineer:	40	\$100.00	\$4,000.00
3.	Measure chiller's condenser water temperature	Plumbing Contractor :	40	\$75.00	\$3,000.00
4.	Hourly Weather data from NWS	Equipment Removal:	20	\$40.00	\$800.00
		Total Cost			\$12,500.00
Chiller Scenario #3: Chiller Retrofit: low Cost/ low Accuracy					
1.	Submeter Chiller at MDP - Log 15 min. data	Plumbing Contractor :	20	\$75.00	\$1,500.00
1a.	Logger calculates Power Consumption	Electrical Contractor:	20	\$75.00	\$1,500.00
2.	Meter chiller temperature - Log 15. min. data	Wiring/Programming Technician:	40	\$50.00	\$2,000.00
3.	Temporary CHW flow metering before/after retrofit	Technician to verify installation:	40	\$50.00	\$2,000.00
4.	Hourly Weather data from NWS	Manager/Project Engineer:	20	\$100.00	\$2,000.00
		Equipment Removal:	20	\$40.00	\$800.00
		Total Cost			\$9,000.00

Figure 66: Labor Costs for Chiller Scenarios.

5.4.1. Chiller Scenario #1: Chiller retrofit – high cost, high accuracy

In this section of the report detailed information is presented for the Chiller Scenario #1, which was developed to demonstrate a high cost, high accuracy metering project to validate lighting savings in a large building.

Savings to include:

- electricity from chiller retrofit normalized for weather, occupancy & operation
- chiller efficiency performance tracked

Analysis method:

- Cross-check of savings using daily whole-building electricity model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily lights and receptacle loads versus daily average NWS
- Cross-check of chiller demand using hourly whole-building electric demand = 24 hour weather daytime profiles of lights and receptacle loads electricity using ASHRAE 1093 Toolkit on presorted data.
- Cross-check using daily chiller electric demand = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of daily chiller electric demand versus daily average temperatures from NWS
- Hourly chiller cooling savings (demand and usage) = chiller performance model using ASHRAE 827 RP models driven by post-retrofit cooling loads

Metering:

- 15-minute whole-building electric using CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute chiller Btu output using flow meter, temperature sensors and integrated Btu meter.

- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses ASHRAE IMT of chiller electricity and 827RP chiller performance models
- Whole-building electricity available to track changes in electricity use if needed.
- Chiller temperature and load data useful for tracking changes in operation

Cons:

- Uses slightly more expensive DAS with integrated wattmeter
- More expensive, requires thermal metering, Btu meters
- More expensive analysis uses redundant models, cross-checks

5.4.1.1. Chiller Scenario #1: Cost Summary

Figure 67 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$39,219.

Cost Summary		
Project	1 Installation	\$21,736
	2 Maintenance	\$1,008
	3 Polling, QC and Data Entry	\$1,061
	4 Equipment Removal	\$1,176
	5 Data Recovery/Missing Data	\$302
	6 One Time Baseline/Post Retrofit Analysis	\$766
	7 Ongoing Savings Analysis	\$1,033
	8 Creating the Basic simulation Input File	\$0
	9 Calibrating Simulation	\$0
	10 Use the Calibrated Simulation to Caculate Baseline	\$0
	11 Use the Calibrated Simulation to Caculate Ongoing	\$0
	12 Reporting	\$1,092
	13 Close-out, Data Transfer	\$130
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$7,072
Total Project Costs		\$39,219

Figure 67: Project.xls Workbook: Chiller Scenario #1 Cost Summary

5.4.2. Chiller Scenario #2: Chiller retrofit - medium cost, medium accuracy

In this section of the report detailed information is presented for the Chiller Scenario #2, which was developed to demonstrate a medium cost, medium accuracy metering project to validate lighting savings in a large building.

Savings to include:

- electricity from chiller retrofit normalized for weather, occupancy & operation
- chiller efficiency performance tracked

Analysis method:

- Hourly chiller cooling savings (demand and usage) = chiller performance model using ASHRAE 827 RP models driven by post-retrofit cooling loads

Metering:

- 15-minute submetering on chiller using CTs, PTs, and integrated wattmeter
- 15-minute chiller Btu output using flow meter, temperature sensors and integrated Btu meter.
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses ASHRAE 827RP chiller performance models
- Chiller temperature and load data useful for tracking changes in operation

Cons:

- Uses slightly more expensive DAS with integrated wattmeter
- More expensive, requires thermal metering, Btu meters
- Cross-check not available if building cooling load changes

5.4.2.1. Chiller Scenario #2: Cost Summary

Figure 68 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$38,436.

Cost Summary		
Project	1 Installation	\$20,895
	2 Maintenance	\$1,008
	3 Polling, QC and Data Entry	\$1,061
	4 Equipment Removal	\$1,176
	5 Data Recovery/Missing Data	\$292
	6 One Time Baseline/Post Retrofit Analysis	\$766
	7 Ongoing Savings Analysis	\$1,033
	8 Creating the Basic simulation Input File	\$0
	9 Calibrating Simulation	\$0
	10 Use the Calibrated Simulation to Caculate Baseline	\$0
	11 Use the Calibrated Simulation to Caculate Ongoing	\$0
	12 Reporting	\$1,301
	13 Close-out, Data Transfer	\$130
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$6,931
Total Project Costs		\$38,436

Figure 68: Project.xls Workbook: Chiller Scenario #2 Cost Summary

5.4.3. Chiller Scenario #3: Chiller retrofit – low cost, low accuracy

In this section of the report detailed information is presented for the Chiller Scenario #3, which was developed to demonstrate a low cost, low accuracy metering project to validate lighting savings in a large building.

Savings to include:

- electricity from chiller retrofit normalized for weather, occupancy & operation
- chiller efficiency performance tracked with before/after snap-shots

Analysis method:

- Hourly chiller cooling savings (demand and usage) = chiller performance model using ASHRAE 827 RP models driven by post-retrofit electricity use
- Portable metering

Metering:

- 15-minute submetering on chiller using CTs, PTs, and integrated wattmeter
- 15-minute chiller temperature sensors
- portable flow meters used before/after retrofit to collect data for 1 month on chiller for developing model.
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses ASHRAE 827RP chiller performance models
- Chiller temperature useful for tracking changes in operation

Cons:

- Uses slightly more expensive DAS with integrated wattmeter
- Relies on snap-shot chiller performance, and continuous chiller electricity measurement.
- Cross-check not available if building cooling load changes

5.4.3.1. Chiller Scenario #3: Cost Summary

Figure 69 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$32,404.

Cost Summary		
Project	1 Installation	\$16,044
	2 Maintenance	\$915
	3 Polling, QC and Data Entry	\$1,061
	4 Equipment Removal	\$1,176
	5 Data Recovery/Missing Data	\$292
	6 One Time Baseline/Post Retrofit Analysis	\$766
	7 Ongoing Savings Analysis	\$1,033
	8 Creating the Basic simulation Input File	\$0
	9 Calibrating Simulation	\$0
	10 Use the Calibrated Simulation to Caculate Baseline	\$0
	11 Use the Calibrated Simulation to Caculate Ongoing	\$0
	12 Reporting	\$1,301
	13 Close-out, Data Transfer	\$130
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$5,843
Total Project Costs		\$32,404

Figure 69: Project.xls Workbook: Chiller Scenario #3 Cost Summary

5.5. EMCS Scenarios.

Three EMCS scenarios were developed to illustrate the use of the M&V Costing Toolkit. The metering assumptions for these scenarios are shown in Figure 70, which include the functional type of data logger,

5.5.1. EMCS Scenario #1: EMCS retrofit – high cost, high accuracy

In this section of the report detailed information is presented for the EMCS Scenario #1, which was developed to demonstrate a high cost, high accuracy metering project to validate lighting savings in a large building.

Savings to include:

- electricity savings from EMCS retrofit normalized for weather and occupancy
- cooling savings due to EMCS retrofit normalized for weather and occupancy
- heating savings due to EMCS retrofit normalized for weather and occupancy
- HVAC efficiency performance tracked
- chiller efficiency performance tracked
- boiler efficiency performance tracked

Analysis method:

- Electricity savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cooling savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Heating savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cross-check using daily whole-building electricity model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus daily average NWS
- Cross-check of electric demand savings using whole-building electric model = 24 hour weather daytype profiles of lights and receptacle loads electricity using ASHRAE 1093 Toolkit on presorted data.
- Cross-check using daily whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus daily average NWS
- Hourly chiller performance model using ASHRAE 827 RP models
- Hourly boiler performance model

Metering:

- 15-minute whole-building electric using CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- 15-minute chiller Btu output using flow meter, temperature sensors and integrated Btu meter.
- 15-minute boiler Btu output using flow meter, temperature sensors and integrated Btu meter.
- 15-minute temperature and environmental monitoring of HVAC systems
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses calibrated air-side HVAC model with cross-check from ASHRAE IMT, 1093 daytype profiles
- Chiller models and boiler models used to track performance

Cons:

- Requires significant temperature and humidity measurements of HVAC systems (usually uses EMCS data)
- Can require continuous air flow measurements of HVAC systems
- Uses slightly more expensive DAS with integrated wattmeter
- More expensive, requires thermal metering, Btu meters.

5.5.1.1. EMCS Scenario #1: Cost Summary

Figure 72 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs,

a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$77,044.

Cost Summary		
Project	1 Installation	\$40,426
	2 Maintenance	\$2,304
	3 Polling, QC and Data Entry	\$1,413
	4 Equipment Removal	\$1,176
	5 Data Recovery/Missing Data	\$394
	6 One Time Baseline/Post Retrofit Analysis	\$1,114
	7 Ongoing Savings Analysis	\$2,008
	8 Creating the Basic simulation Input File	\$3,132
	9 Calibrating Simulation	\$3,200
	10 Use the Calibrated Simulation to Caculate Baseline	\$1,160
	11 Use the Calibrated Simulation to Caculate Ongoing	\$1,550
	12 Reporting	\$1,301
	13 Close-out, Data Transfer	\$130
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$13,893
Total Project Costs		\$77,044

Figure 72: Project.xls Workbook: EMCS #1 Cost Summary

5.5.2. EMCS Scenario #2: EMCS retrofit - medium cost, medium accuracy

In this section of the report detailed information is presented for the EMCS Scenario #2, which was developed to demonstrate a medium cost, medium accuracy metering project to validate lighting savings in a large building.

Savings to include:

- electricity savings from EMCS retrofit normalized for weather and occupancy
- cooling savings due to EMCS retrofit normalized for weather and occupancy
- heating savings due to EMCS retrofit normalized for weather and occupancy
- HVAC efficiency performance calculated from snap-shot measurements

Analysis method:

- Electricity savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cooling savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Heating savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cross-check using daily whole-building electricity model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus daily average NWS
- Cross-check of electric demand savings using whole-building electric model = 24 hour weather daytype profiles of lights and receptacle loads electricity using ASHRAE 1093 Toolkit on presorted data.
- Cross-check using daily whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus daily average NWS

Metering:

- 15-minute whole-building electric using CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- before/after snap-shot temperature and environmental measurements of HVAC systems using portable loggers
- digital DAS with integrated wattmeter

- hourly weather data from NWS

Pros:

- uses closest NWS
- analysis uses air-side HVAC model calibrated with snap-shot data
- cross-check from daily ASHRAE IMT, 1093 daytype profiles
- uses less expensive digital loggers
- uses less expensive portable loggers for snap-shot measurements of HVAC systems

Cons:

- Does not continuously track HVAC performance
- Does not continuously track chiller performance
- Does not continuously track boiler performance

5.5.2.1. EMCS Scenario #2: Cost Summary

Figure 73 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$51,571.

Cost Summary		
Project	1 Installation	\$22,357
	2 Maintenance	\$1,215
	3 Polling, QC and Data Entry	\$1,061
	4 Equipment Removal	\$1,176
	5 Data Recovery/Missing Data	\$348
	6 One Time Baseline/Post Retrofit Analysis	\$766
	7 Ongoing Savings Analysis	\$1,033
	8 Creating the Basic simulation Input File	\$3,132
	9 Calibrating Simulation	\$3,200
	10 Use the Calibrated Simulation to Caculate Baseline	\$1,160
	11 Use the Calibrated Simulation to Caculate Ongoing	\$1,550
	12 Reporting	\$1,301
	13 Close-out, Data Transfer	\$130
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$9,300
Total Project Costs		\$51,571

Figure 73: Project.xls Workbook: EMCS #2 Cost Summary

5.5.3. EMCS Scenario #3: EMCS retrofit – low cost, low accuracy

In this section of the report detailed information is presented for the EMCS Scenario #3, which was developed to demonstrate a low cost, low accuracy metering project to validate lighting savings in a large building.

Savings to include:

- electricity savings from EMCS retrofit normalized for weather and occupancy
- cooling savings due to EMCS retrofit normalized for weather and occupancy
- heating savings due to EMCS retrofit normalized for weather and occupancy
- HVAC efficiency performance calculated from snap-shot measurements

Analysis method:

- Electricity savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cooling savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Heating savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cross-check using monthly whole-building electricity model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus billing period average NWS
- Cross-check using monthly whole-building electricity model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus billing period average NWS
- Cross-check using monthly whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus billing period average NWS
- Cross-check using monthly whole-building electric demand model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus billing period peak NWS

Metering:

- 15-minute whole-building electric using portable logger with CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using portable logger with CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute whole building nat gas using portable logger with existing pulse from gas meter (let's assume this exists).
- before/after snap-shot temperature and environmental measurements of HVAC systems using portable loggers
- digital DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- uses closest NWS
- analysis uses air-side HVAC model calibrated with snap-shot data
- cross-check from ASHRAE IMT using monthly data
- uses less expensive portable loggers for snap-shot measurements of HVAC systems

Cons:

- Does not continuously track HVAC performance
- Does not continuously track chiller performance
- Does not continuously track boiler performance
- Monthly cross-check less accurate than daily cross-check

5.5.3.1. EMCS Scenario #3: Cost Summary

Figure 74 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$45,731.

		LABOR HOURS			
		Metering Installation Labor in Hours (does not include engineering analysis)			
				Labor Cost per Hour	Total Cost per Labor Category
Boiler Scenario #1: Boiler Retrofit: high Cost/ high Accuracy					
1.	Logger calculates HW Energy consumption -Log 15 min. data	Plumbing Contractor:	40	\$75.00	\$3,000.00
1a.	Install flow meters and temperature sensors	Manager/Project Engineer:	20	\$100.00	\$2,000.00
2.	Duplicate Gas Utility Meter Pulse - Log 15 min. data	Wiring/Programming Technician:	40	\$50.00	\$2,000.00
3.	Hourly Weather data from NWS	Technician to verify installation:	40	\$50.00	\$2,000.00
		PreMAP:	40	\$116.00	\$4,640.00
		Equipment Removal:	10	\$40.00	\$400.00
		Total Cost			\$9,000.00
Boiler Scenario #2: Boiler Retrofit: med. Cost/ med. Accuracy					
1.	Duplicate Gas Utility Meter Pulse - Log 15 min. data	Manager/Project Engineer:	20	\$100.00	\$2,000.00
2.	Snapshot of HW Energy consumption before/after retrofit	Wiring/Programming Technician:	20	\$50.00	\$1,000.00
2a.	Temporary flow meters and temperature sensors	Technician to verify installation:	40	\$50.00	\$2,000.00
3.	Hourly Weather data from NWS	PreMAP:	40	\$116.00	\$4,640.00
		Equipment Removal:	10	\$40.00	\$400.00
		Total Cost			\$5,000.00
Boiler Scenario #3: Boiler Retrofit: low Cost/ low Accuracy					
1.	Duplicate Gas Utility Meter Pulse - Log 15 min. data	Manager/Project Engineer:	20	\$100.00	\$2,000.00
2.	Snapshot of HW Energy consumption before/after retrofit	Wiring/Programming Technician:	40	\$50.00	\$2,000.00
2a.	Temporary flow meters and temperature sensors	Technician to verify installation:	40	\$50.00	\$2,000.00
3.	Hourly Weather data from NWS	PreMAP:	20	\$116.00	\$2,320.00
		Equipment Removal:	10	\$40.00	\$400.00
		Total Cost			\$6,000.00

Figure 76: Labor Costs for Boiler Scenarios.

5.6.1. Boiler Scenario #1: Boiler retrofit – high cost, high accuracy

In this section of the report detailed information is presented for the Boiler Scenario #1, which was developed to demonstrate a high cost, high accuracy metering project to validate lighting savings in a large building.

Savings to include:

- Natural gas from boiler retrofit normalized for weather
- Boiler efficiency performance tracked

Analysis method:

- Cross-check of savings using daily whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE loads versus daily average NWS
- Hourly boiler heating savings = boiler performance model driven by post-retrofit heating loads

Metering:

- 15-minute boiler Btu output using flow meter, temperature sensors and integrated Btu meter.
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses boiler performance models with cross-check from whole-building model.
- Boiler temperature and load data useful for tracking changes in operation

Cons:

- Uses slightly more expensive analog/digital DAS
- More expensive, requires thermal metering, Btu meters
- More expensive analysis uses redundant models, cross-checks

5.6.1.1. Boiler Scenario #1: Cost Summary

Figure 77 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$34,596.

Cost Summary		
Project	1 Installation	\$17,726
	2 Maintenance	\$1,438
	3 Polling, QC and Data Entry	\$1,061
	4 Equipment Removal	\$776
	5 Data Recovery/Missing Data	\$284
	6 One Time Baseline/Post Retrofit Analysis	\$766
	7 Ongoing Savings Analysis	\$1,033
	8 Creating the Basic simulation Input File	\$0
	9 Calibrating Simulation	\$0
	10 Use the Calibrated Simulation to Caculate Baseline	\$0
	11 Use the Calibrated Simulation to Caculate Ongoing	\$0
	12 Reporting	\$1,301
	13 Close-out, Data Transfer	\$130
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$6,239
Total Project Costs		\$34,596

Figure 77: Project.xls Workbook: Boiler #1 Cost Summary

5.6.2. Boiler Scenario #2: Boiler retrofit - medium cost, medium accuracy

In this section of the report detailed information is presented for the Boiler Scenario #2, which was developed to demonstrate a medium cost, medium accuracy metering project to validate lighting savings in a large building.

Savings to include:

- Natural gas from boiler retrofit normalized for weather
- Boiler efficiency performance measured with before/after snap shot measurements

Analysis method:

- Cross-check of savings using daily whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE loads versus daily average NWS
- Hourly boiler heating savings = boiler performance model driven by post-retrofit heating loads

Metering:

- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- Snap-shot before/after boiler efficiency measurements using flow and temperature with portable loggers
- Digital DAS
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses snap-shot boiler performance models with cross-check from whole-building model.

Cons:

- Uses slightly less expensive digital DAS and portable snap-shot boiler efficiency measurements
- Does not track boiler performance

5.6.2.1. Boiler Scenario #2: Cost Summary

Figure 78 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$25,989.

Cost Summary		
Project	1 Installation	\$12,030
	2 Maintenance	\$796
	3 Polling, QC and Data Entry	\$1,072
	4 Equipment Removal	\$776
	5 Data Recovery/Missing Data	\$113
	6 One Time Baseline/Post Retrofit Analysis	\$418
	7 Ongoing Savings Analysis	\$1,033
	8 Creating the Basic simulation Input File	\$0
	9 Calibrating Simulation	\$0
	10 Use the Calibrated Simulation to Caculate Baseline	\$0
	11 Use the Calibrated Simulation to Caculate Ongoing	\$0
	12 Reporting	\$1,092
	13 Close-out, Data Transfer	\$130
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$4,686
Total Project Costs		\$25,989

Figure 78: Project.xls Workbook: Boiler #2 Cost Summary

5.6.3. Boiler Scenario #3: Boiler retrofit – low cost, low accuracy

In this section of the report detailed information is presented for the Boiler Scenario #3, which was developed to demonstrate a high cost, high accuracy metering project to validate lighting savings in a large building.

Savings to include:

- Natural gas from boiler retrofit normalized for weather
- Boiler efficiency performance measured with before/after snap shot measurements

Analysis method:

- monthly whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE loads versus billing period average NWS
- boiler performance = before/after snap-shot measurements used to determine if boiler is capable of operating efficiently

Metering:

- monthly gas use from utility bill

- Snap-shot before/after boiler efficiency measurements using flow and temperature with portable loggers
- Daily weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses monthly whole-building natural gas model with cross-check from snap-shot boiler performance models

Cons:

- Uses less portable DAS and portable snap-shot boiler efficiency measurements
- Does not track boiler performance

5.6.3.1. Boiler Scenario #3 Cost Summary

Figure 79 shows the ten costs categories associated with using long term M&V with data loggers, including a one-time cost for equipment installation, an annual maintenance cost, annual polling, QC and data entry costs, a one-time equipment removal cost, a data recovery cost, a one-time baseline model cost, a ongoing savings analysis cost, a reporting cost, a project close-out cost, and a cost associated with gathering the hourly weather data, which totals \$18,457.

Cost Summary		
Project	1 Installation	\$7,712
	2 Maintenance	\$22
	3 Polling, QC and Data Entry	\$245
	4 Equipment Removal	\$312
	5 Data Recovery/Missing Data	\$113
	6 One Time Baseline/Post Retrofit Analysis	\$418
	7 Ongoing Savings Analysis	\$1,033
	8 Creating the Basic simulation Input File	\$0
	9 Calibrating Simulation	\$0
	10 Use the Calibrated Simulation to Caculate Baseline	\$0
	11 Use the Calibrated Simulation to Caculate Ongoing	\$0
	12 Reporting	\$1,301
	13 Close-out, Data Transfer	\$130
Weather	1 Hourly Weather Data	\$3,843
	Overheads & Profits	\$3,328
Total Project Costs		\$18,457

Figure 79: Project.xls Workbook: Boiler #3 Cost Summary

6. SUMMARY

This report has presented a general overview of the M&V costing process, various methods for monitoring and verifying savings, and a description of the M&V Costing Toolkit. In addition, examples of the use of the M&V Costing Toolkit have also been presented.

This report has presented two types of M&V methods that have been consolidated from the original four M&V methods presented in the 2001 report have, which included: a) a monthly utility billing analysis, b) long-term M&V, c) short-term M&V, and d) a calibrated simulation method. The methods presented in this report include: a) monthly utility billing method, and b) short or long term monitoring with data loggers or EMCS.

This M&V Costing Toolkit includes three general MS Excel workbooks, including:

- Project.xls
- Utility.xls
- Fort Hood M&V Equipment Costs.xls

Each toolkit consists of one self-contained MS Excel workbook, where each workbook represents a different M&V method. Each workbook includes a cost summary and detailed costing information. Labor costs and weather information spreadsheet are included in all workbooks.

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METERING SCENARIOS FOR CERL M&V COSTING TOOLKIT
REVISED 7/14/2003

SUMMARY OF SCENARIOS

Lighting Scenario #1: Lighting retrofit – high cost, high accuracy

Lighting Scenario #2A: Lighting retrofit – medium-high cost, medium-high accuracy

Lighting Scenario #2B: Lighting retrofit - medium cost, medium accuracy

Lighting Scenario #3: Lighting retrofit – low cost, low accuracy

Chiller Scenario #1: Chiller retrofit – high cost, high accuracy

Chiller Scenario #2: Chiller retrofit - medium cost, medium accuracy

Chiller Scenario #3: Chiller retrofit – low cost, low accuracy

EMCS Scenario #1: EMCS retrofit – high cost, high accuracy

EMCS Scenario #2: EMCS retrofit - medium cost, medium accuracy

EMCS Scenario #3: EMCS retrofit – low cost, low accuracy

Boiler Scenario #1: Boiler retrofit – high cost, high accuracy

Boiler Scenario #2: Boiler retrofit - medium cost, medium accuracy

Boiler Scenario #3: Boiler retrofit – low cost, low accuracy

DETAILED SCENARIOS:

Lighting Scenario #1: Lighting retrofit – high cost, high accuracy

Savings to include:

- electricity savings from lighting retrofit normalized for occupancy
- cooling savings due to lighting retrofit normalized for weather
- additional heating gas use to make up for lighting retrofit normalized for weather
- chiller efficiency performance tracked
- boiler efficiency performance tracked

Analysis method:

- Daily electricity savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily lights and receptacle loads versus daily average NWS
- Hourly electric demand = 24 hour weather daytype profiles of lights and receptacle loads electricity using ASHRAE 1093 Toolkit on presorted data.
- Daily cooling savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE MCC electricity use versus daily average NWS
- Daily heating increase = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily whole-building gas use versus daily average NWS
- Hourly chiller performance model using ASHRAE 827 RP models
- Hourly boiler performance model

Metering:

- 15-minute whole-building electric using CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- 15-minute chiller Btu output using flow meter, temperature sensors and integrated Btu meter.
- 15-minute boiler Btu output using flow meter, temperature sensors and integrated Btu meter.
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses ASHRAE IMT, chiller models, boiler models, 1093 daytype profiles
- Electricity savings of lighting and receptacles normalized for weather and weekday/weekend.
- Separate electricity savings of cooling electricity use normalized for weather and weekday/weekend
- Natural gas take-back normalized for weather and weekday/weekend.

Cons:

- Weather dependent and weather independent savings combined into one model.
- Uses slightly more expensive DAS with integrated wattmeter
- More expensive, requires thermal metering, Btu meters.

Lighting Scenario #2A: Lighting retrofit – medium-high cost, medium-high accuracy

Savings to include:

- electricity from lighting retrofit normalized for occupancy
- cooling savings due to lighting retrofit normalized for weather
- additional heating gas to make up for lighting retrofit normalized for weather

Analysis method:

- Daily electricity savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily lights and receptacle loads versus daily average NWS
- Hourly electric demand = 24 hour weather daytype profiles of lights and receptacle loads electricity using ASHRAE 1093 Toolkit on presorted data.
- Daily cooling electricity savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE MCC electricity use versus daily average NWS
- Daily natural gas increase = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily whole-building gas use versus daily average NWS

Metering:

- 15-minute whole-building electric using CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Simple to install.
- Uses CTs, PTs and integrated wattmeters
- Uses closest NWS
- Analysis relatively simple, uses ASHRAE IMT and daytype profiles
- Electricity savings of lighting and receptacles normalized for weather and weekday/weekend.
- Separate electricity savings of cooling electricity use normalized for weather and weekday/weekend
- Natural gas take-back normalized for weather and weekday/weekend.

Cons:

- Weather dependent and weather independent savings combined into one model.
- Uses slightly more expensive DAS with integrated wattmeter
- Not normalized for:
 - Changes in chiller efficiency or operation
 - Changes in boiler efficiency or operation

Lighting Scenario #2B: Lighting retrofit - medium cost, medium accuracy

Savings to include:

- electricity from combined lighting retrofit, and cooling savings due to lighting retrofit normalized for weather
- additional natural gas to make up for lighting retrofit normalized for weather
- electricity from lighting retrofit normalized for occupancy

Analysis method:

- Daily electricity savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily whole-building electricity versus daily average NWS
- Hourly electric demand = 24 hour weather daytype profiles of whole-building electricity using ASHRAE 1093 Toolkit on presorted data.
- Daily natural gas increase = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily whole-building gas use versus daily average NWS

Metering:

- 15-minute whole building electric using pulse from main meter
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- digital DAS
- hourly weather data from NWS

Pros:

- Simple to install.
- Uses digital pulse from existing meters
- Uses inexpensive digital DAS
- Uses closest NWS
- Analysis relatively simple, uses ASHRAE IMT
- Electricity savings normalized for weather and weekday/weekend.
- Natural gas take-back normalized for weather and weekday/weekend.

Cons:

- Weather dependent and weather independent savings combined into one model.
- Not normalized for:
 - Changes in chiller efficiency or operation
 - Changes in boiler efficiency or operation
 - Changes in occupancy patterns
 - Lamp burn-outs, replacements

Lighting Scenario #3: Lighting retrofit – low cost, low accuracy

Savings to include:

- electricity from combined lighting retrofit, and cooling savings due to lighting retrofit normalized for weather
- additional natural gas to make up for lighting retrofit normalized for weather

Analysis method:

- Monthly electricity savings = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of monthly whole-building electricity versus average NWS for the billing period
- Monthly electric demand = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of monthly whole-building electric demand versus max temperatures from NWS for the billing period
- Cross-check of lighting savings = combination of blink test of before/after loads to confirm calculations of peak lighting load reductions and usage profiles from lighting loggers
- Monthly natural gas increase = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of monthly whole-building gas use versus average NWS for the billing period

Metering:

- Monthly utility bills for electricity use and electric demand
- Monthly utility bills for natural gas
- 5-minute whole building electric using portable meter
- hourly weather data from NWS
- 1 month of lighting loggers to confirm lighting use profiles before and after lighting retrofits

Pros:

- Simple to install, requires one weekend before/after retrofit for blink tests.
- Uses digital pulse from existing electricity meter
- Uses inexpensive portable digital DAS
- Uses closest NWS
- Analysis relatively simple, uses ASHRAE IMT, 1093 toolkit and blink test data
- Electricity savings normalized for monthly weather
- Natural gas take-back normalized for monthly weather
- Can detect changes in occupancy patterns using lighting loggers
- Can detect changes in large numbers of lamp burn-outs, replacements using blink test.

Cons:

- Weather dependent and weather independent savings combined into one monthly model.
- Requires placing and retrieving lighting loggers.
- Requires blink test to be run before/after lighting retrofit
- Not normalized for:
 - Changes in chiller efficiency or operation
 - Changes in boiler efficiency or operation

Chiller Scenario #1: Chiller retrofit – high cost, high accuracy

Savings to include:

- electricity from chiller retrofit normalized for weather, occupancy & operation
- chiller efficiency performance tracked

Analysis method:

- Cross-check of savings using daily whole-building electricity model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE daily lights and receptacle loads versus daily average NWS
- Cross-check of chiller demand using hourly whole-building electric demand = 24 hour weather daytype profiles of lights and receptacle loads electricity using ASHRAE 1093 Toolkit on presorted data.
- Cross-check using daily chiller electric demand = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of daily chiller electric demand versus daily average temperatures from NWS
- Hourly chiller cooling savings (demand and usage) = chiller performance model using ASHRAE 827 RP models driven by post-retrofit cooling loads

Metering:

- 15-minute whole-building electric using CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute chiller Btu output using flow meter, temperature sensors and integrated Btu meter.
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses ASHRAE IMT of chiller electricity and 827RP chiller performance models
- Whole-building electricity available to track changes in electricity use if needed.
- Chiller temperature and load data useful for tracking changes in operation

Cons:

- Uses slightly more expensive DAS with integrated wattmeter
- More expensive, requires thermal metering, Btu meters
- More expensive analysis uses redundant models, cross-checks

Chiller Scenario #2: Chiller retrofit - medium cost, medium accuracy

Savings to include:

- electricity from chiller retrofit normalized for weather, occupancy & operation
- chiller efficiency performance tracked

Analysis method:

- Hourly chiller cooling savings (demand and usage) = chiller performance model using ASHRAE 827 RP models driven by post-retrofit cooling loads

Metering:

- 15-minute submetering on chiller using CTs, PTs, and integrated wattmeter
- 15-minute chiller Btu output using flow meter, temperature sensors and integrated Btu meter.
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses ASHRAE 827RP chiller performance models
- Chiller temperature and load data useful for tracking changes in operation

Cons:

- Uses slightly more expensive DAS with integrated wattmeter
- More expensive, requires thermal metering, Btu meters
- Cross-check not available if building cooling load changes

Chiller Scenario #3: Chiller retrofit – low cost, low accuracy

Savings to include:

- electricity from chiller retrofit normalized for weather, occupancy & operation
- chiller efficiency performance tracked with before/after snap-shots

Analysis method:

- Hourly chiller cooling savings (demand and usage) = chiller performance model using ASHRAE 827 RP models driven by post-retrofit electricity use
- Portable metering

Metering:

- 15-minute submetering on chiller using CTs, PTs, and integrated wattmeter
- 15-minute chiller temperature sensors
- portable flow meters used before/after retrofit to collect data for 1 month on chiller for developing model.
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses ASHRAE 827RP chiller performance models
- Chiller temperature useful for tracking changes in operation

Cons:

- Uses slightly more expensive DAS with integrated wattmeter
- Relies on snap-shot chiller performance, and continuous chiller electricity measurement.
- Cross-check not available if building cooling load changes

EMCS Scenario #1: EMCS retrofit – high cost, high accuracy

Savings to include:

- electricity savings from EMCS retrofit normalized for weather and occupancy
- cooling savings due to EMCS retrofit normalized for weather and occupancy
- heating savings due to EMCS retrofit normalized for weather and occupancy
- HVAC efficiency performance tracked
- chiller efficiency performance tracked
- boiler efficiency performance tracked

Analysis method:

- Electricity savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cooling savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Heating savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cross-check using daily whole-building electricity model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus daily average NWS
- Cross-check of electric demand savings using whole-building electric model = 24 hour weather daytype profiles of lights and receptacle loads electricity using ASHRAE 1093 Toolkit on presorted data.
- Cross-check using daily whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus daily average NWS
- Hourly chiller performance model using ASHRAE 827 RP models
- Hourly boiler performance model

Metering:

- 15-minute whole-building electric using CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- 15-minute chiller Btu output using flow meter, temperature sensors and integrated Btu meter.
- 15-minute boiler Btu output using flow meter, temperature sensors and integrated Btu meter.
- 15-minute temperature and environmental monitoring of HVAC systems
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses calibrated air-side HVAC model with cross-check from ASHRAE IMT, 1093 daytype profiles
- Chiller models and boiler models used to track performance

Cons:

- Requires significant temperature and humidity measurements of HVAC systems (usually uses EMCS data)
- Can require continuous air flow measurements of HVAC systems
- Uses slightly more expensive DAS with integrated wattmeter
- More expensive, requires thermal metering, Btu meters.

EMCS Scenario #2: EMCS retrofit - medium cost, medium accuracy

Savings to include:

- electricity savings from EMCS retrofit normalized for weather and occupancy
- cooling savings due to EMCS retrofit normalized for weather and occupancy
- heating savings due to EMCS retrofit normalized for weather and occupancy
- HVAC efficiency performance calculated from snap-shot measurements

Analysis method:

- Electricity savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cooling savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Heating savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cross-check using daily whole-building electricity model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus daily average NWS
- Cross-check of electric demand savings using whole-building electric model = 24 hour weather daytype profiles of lights and receptacle loads electricity using ASHRAE 1093 Toolkit on presorted data.
- Cross-check using daily whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus daily average NWS

Metering:

- 15-minute whole-building electric using CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- before/after snap-shot temperature and environmental measurements of HVAC systems using portable loggers
- digital DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- uses closest NWS
- analysis uses air-side HVAC model calibrated with snap-shot data
- cross-check from daily ASHRAE IMT, 1093 daytype profiles
- uses less expensive digital loggers
- uses less expensive portable loggers for snap-shot measurements of HVAC systems

Cons:

- Does not continuously track HVAC performance
- Does not continuously track chiller performance
- Does not continuously track boiler performance

EMCS Scenario #3: EMCS retrofit – low cost, low accuracy

Savings to include:

- electricity savings from EMCS retrofit normalized for weather and occupancy
- cooling savings due to EMCS retrofit normalized for weather and occupancy
- heating savings due to EMCS retrofit normalized for weather and occupancy
- HVAC efficiency performance calculated from snap-shot measurements

Analysis method:

- Electricity savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cooling savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Heating savings = calibrated air-side HVAC model (ASHRAE 865RP) using hourly NWS data
- Cross-check using monthly whole-building electricity model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus billing period average NWS
- Cross-check using monthly whole-building electricity model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus billing period average NWS
- Cross-check using monthly whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus billing period average NWS
- Cross-check using monthly whole-building electric demand model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE whole-building loads versus billing period peak NWS

Metering:

- 15-minute whole-building electric using portable logger with CTs and PTs on the main feeds, and integrated watt meter
- 15-minute submetering on MCC using using portable logger with CTs, PTs, and integrated wattmeter (including chillers, pumps, etc.).
- 15-minute whole building nat gas using using portable logger with existing pulse from gas meter (let's assume this exists).
- before/after snap-shot temperature and environmental measurements of HVAC systems using portable loggers
- digital DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- uses closest NWS
- analysis uses air-side HVAC model calibrated with snap-shot data
- cross-check from ASHRAE IMT using monthly data
- uses less expensive expensive portable loggers for snap-shot measurements of HVAC systems

Cons:

- Does not continuously track HVAC performance
- Does not continuously track chiller performance
- Does not continuously track boiler performance
- Monthly cross-check less accurate than daily cross-check

Boiler Scenario #1: Boiler retrofit – high cost, high accuracy

Savings to include:

- Natural gas from boiler retrofit normalized for weather
- Boiler efficiency performance tracked

Analysis method:

- Cross-check of savings using daily whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE loads versus daily average NWS
- Hourly boiler heating savings = boiler performance model driven by post-retrofit heating loads

Metering:

- 15-minute boiler Btu output using flow meter, temperature sensors and integrated Btu meter.
- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- digital/analog DAS with integrated wattmeter
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses boiler performance models with cross-check from whole-building model.
- Boiler temperature and load data useful for tracking changes in operation

Cons:

- Uses slightly more expensive analog/digital DAS
- More expensive, requires thermal metering, Btu meters
- More expensive analysis uses redundant models, cross-checks

Boiler Scenario #2: Boiler retrofit - medium cost, medium accuracy

Savings to include:

- Natural gas from boiler retrofit normalized for weather
- Boiler efficiency performance measured with before/after snap shot measurements

Analysis method:

- Cross-check of savings using daily whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE loads versus daily average NWS
- Hourly boiler heating savings = boiler performance model driven by post-retrofit heating loads

Metering:

- 15-minute whole building nat gas using existing pulse from gas meter (let's assume this exists).
- Snap-shot before/after boiler efficiency measurements using flow and temperature with portable loggers
- Digital DAS
- hourly weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses snap-shot boiler performance models with cross-check from whole-building model.

Cons:

- Uses slightly less expensive digital DAS and portable snap-shot boiler efficiency measurements
- Does not track boiler performance

Boiler Scenario #3: Boiler retrofit – low cost, low accuracy

Savings to include:

- Natural gas from boiler retrofit normalized for weather
- Boiler efficiency performance measured with before/after snap shot measurements

Analysis method:

- monthly whole-building natural gas model = 1, 2, 3, 4 or 5P weather dependent model (ASHRAE IMT) of WD/WE loads versus billing period average NWS
- boiler performance = before/after snap-shot measurements used to determine if boiler is capable of operating efficiently

Metering:

- monthly gas use from utility bill
- Snap-shot before/after boiler efficiency measurements using flow and temperature with portable loggers
- Daily weather data from NWS

Pros:

- Uses closest NWS
- Analysis uses monthly whole-building natural gas model with cross-check from snap-shot boiler performance models

Cons:

- Uses less portable DAS and portable snap-shot boiler efficiency measurements
- Does not track boiler performance