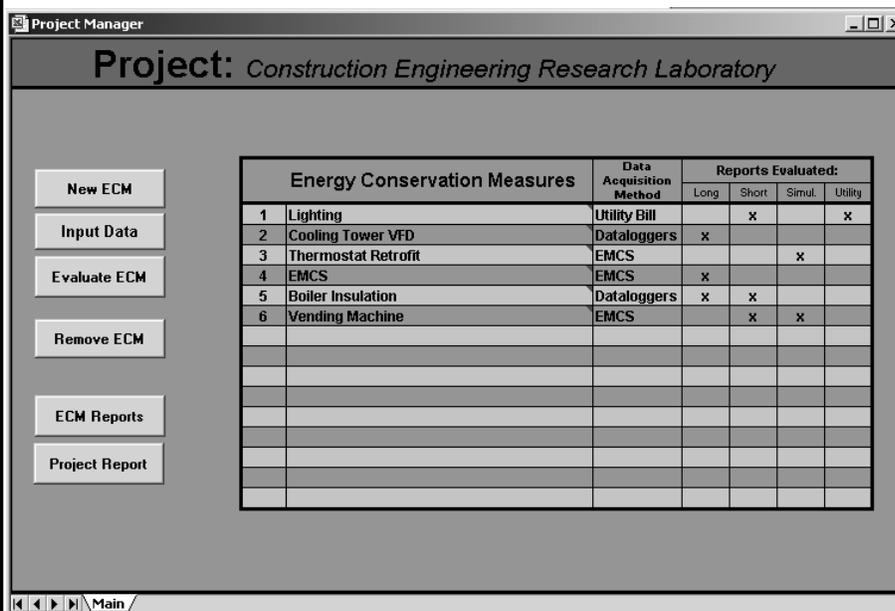




# Energy Savings Measurement and Verification Toolkit Guide v2.96

Noah Zych, Matt Pennell, and Dave Underwood

July 2003



## Foreword

This study was conducted for [[Name of Sponsoring Organization]] under [[RDTE project number, "Project Title"; Work Unit number, "Work Unit Title."]] The technical monitor was [[Full Name(s), Office Code]].

The work was performed by the Energy Branch (CF-E) of the Facilities Division, Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Dave Underwood. Part of this work was done by Texas Engineering Experiment Station, 332 Wisenbaker Engineering Research Center, College Station, TX 77843 under contracts No. DACA42-03-P-0102 and No. DACA42-01-F-0098. The technical editor was [[Editor's Full Name]], Information Technology Laboratory. Dr. Thomas Hartranft is Chief, CEERD-CF-E, and Michael Golish is Chief, CEERD-CF. The associated Technical Director was [[Full TD Name]], [[CEERD-CX-X]]. The Director of CERL is Dr. Alan W. Moore.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL James R. Rowan, and the Director of ERDC is Dr. James R. Houston.

**DISCLAIMER:** The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. All product names and trademarks cited are the property of their respective owners. The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.  
**DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED. DO NOT RETURN IT TO THE ORIGINATOR.**

# Contents

<b>Foreword</b> .....	<b>2</b>
<b>List of Figures and Tables</b> .....	<b>5</b>
<b>1 Introduction</b> .....	<b>7</b>
Background.....	7
Objective.....	7
Approach .....	8
Mode of Technology Transfer .....	8
Units of Weight and Measure .....	8
<b>2 Installation Guide</b> .....	<b>10</b>
System Requirements .....	10
Installation Instructions .....	10
<b>3 Overview</b> .....	<b>12</b>
M&V Toolkit.....	12
Project Manager .....	13
Data Input .....	14
Cost Reports.....	15
<b>4 Tutorial</b> .....	<b>17</b>
Starting Off.....	17
Creating a New Project.....	17
Adding an ECM.....	18
Entering Project-level Cost Data .....	19
Entering ECM Level Data .....	22
Evaluating an ECM.....	27
Viewing ECM Reports.....	28
Compiling and Viewing Project Level Reports.....	32
Changing Data.....	36
<b>5 Glossary</b> .....	<b>37</b>
<b>6 Formulas and Macros</b> .....	<b>39</b>
M&V Toolkit.xls.....	39
Project Manager.xls .....	40



# List of Figures and Tables

## Figures

1	List of zipped files.....	10
2	Setting extraction options.....	11
3	Typical directory tree listing after installation .....	131
4	The M&V Toolkit window .....	13
5	The Project Manager window.....	14
6	A data input sheet.....	15
7	A cost report sheet .....	16
8	The M&V Toolkit folder .....	17
9	Creating a new project .....	18
10	Adding an ECM to a project .....	19
11	The Input Data window .....	19
12	Setting wages for laborers .....	20
13	The travel cost input data sheet.....	21
14	Entering task hours information for an ECM .....	21
15	Inputting weather data costs .....	22
16	Setting the contractor's overhead and profits percentage .....	22
17	The equipment manager .....	23
18	Choosing equipment for an ECM.....	24
19	Viewing a detailed description of a piece of equipment.....	24
20	Modifying the number of hours allotted for tasks for a piece of equipment .....	25
21	Removing a piece of equipment.....	26
22	Entering data manipulation costs for an ECM.....	26
23	Evaluate Data window.....	27
24	Missing data that must be entered before evaluation .....	28
25	View reports window .....	28
26	Mega-summary with details for all costs .....	29
27	The Equipment report .....	30
28	Labor cost report .....	31
29	Travel cost report .....	31

30 Weather cost report..... 32

31 Annual cost report ..... 32

32 Selecting ECMs to include in the Compile Project Report window ..... 33

33 Selecting the M&V method for each ECM in the project report ..... 33

34 The Project Summary ..... 34

35 Equipment costs for the entire project..... 34

36 The travel costs summary for the whole project ..... 35

37 The project-level labor report ..... 35

38 Annual weather costs summary in the Project Report..... 36

# 1 Introduction

## Background

The federal government currently spends billions of dollars paying for energy, and many building systems run at less than optimum efficiency. Replacing old and inefficient equipment with newer, better equipment can reduce many of these costs. This can even be done without any capital investments by the government if an Energy Savings Performance Contract (ESPC) is used. ESPCs make energy conservation a more viable option for cash-strapped agencies, because the contractor absorbs initial costs and is repaid through utility bill savings. However, as in all energy savings projects, it is necessary to measure and verify the actual savings if the realized savings are to be known. This is especially critical for ESPCs, because by law only verified energy savings can be used to pay for ESPC Costs. A measurement and verification (M&V) plan must be custom tailored to each project in order to ensure that it is cost effective and meaningful.

The M&V Toolkit described herein is a utility that can be used to estimate M&V costs, and it allows a user to determine what method of monitoring will provide the necessary data at an acceptable cost. The basis for this toolkit was originally developed by the Energy Systems Laboratory (ESL) at Texas A&M University, and was expanded and modified at ERDC Construction Engineering Research Laboratory (CERL). The toolkit estimates costs for four M&V methods (organized by methods of gathering data), each compatible with IPMVP 2001 and AHRAE Guideline 14 standards. The methods included are a long-term analysis, a short-term analysis, a monthly utility bill analysis, and a calibrated simulation model. The toolkit is based on a collection of Microsoft Excel workbooks, with automated cost data entry and evaluation.

## Objective

The objective of this project is to provide a user-friendly method of quickly estimating M&V costs for various energy conservation methods (ECMs) and M&V options, in order to determine the most cost effective monitoring method. This

report provides an overview of the project, and is a user manual for the cost-estimating toolkit.

## Approach

ESL developed an initial set of spreadsheets incorporating all financial aspects of measuring and verifying a project. CERL then compiled these spreadsheets and added a user interface and automated report generation.

## Mode of Technology Transfer

The information in this report will be used by government and commercial planners to utilize the toolkit and determine an appropriate M&V plan for their specific projects.

This report will be made accessible through the World Wide Web (WWW) at URL:

<http://www.cecer.army.mil/mvtoolkit>

## Units of Weight and Measure

U.S. standard units of measure are used throughout this report. A table of conversion factors for Standard International (SI) units is provided below.

SI conversion factors		
1 in.	=	2.54 cm
1 ft	=	0.305 m
1 yd	=	0.9144 m
1 sq in.	=	6.452 cm <sup>2</sup>
1 sq ft	=	0.093 m <sup>2</sup>
1 sq yd	=	0.836 m <sup>2</sup>
1 cu in.	=	16.39 cm <sup>3</sup>
1 cu ft	=	0.028 m <sup>3</sup>
1 cu yd	=	0.764 m <sup>3</sup>
1 gal	=	3.78 L
1 lb	=	0.453 kg
1 kip	=	453 kg
1 psi	=	6.89 kPa
°F	=	(°C x 1.8) + 32



## 2 Installation Guide

### System Requirements

This toolkit requires Microsoft Excel 2000 or higher, and at least 10MB of hard disk space. Additional space is required for each project.

### Installation Instructions

Note: these instructions are specific to utilizing WinZip as the extraction utility; they are, however, general enough to apply to most utilities.

1. Double-click the current .zip archive containing the toolkit. The archive will open and the contents will be displayed in your extraction utility. (If you do not have one, several are available for free download on the Internet, such as WinZip.)
2. Click the “Extract” button to extract the files.

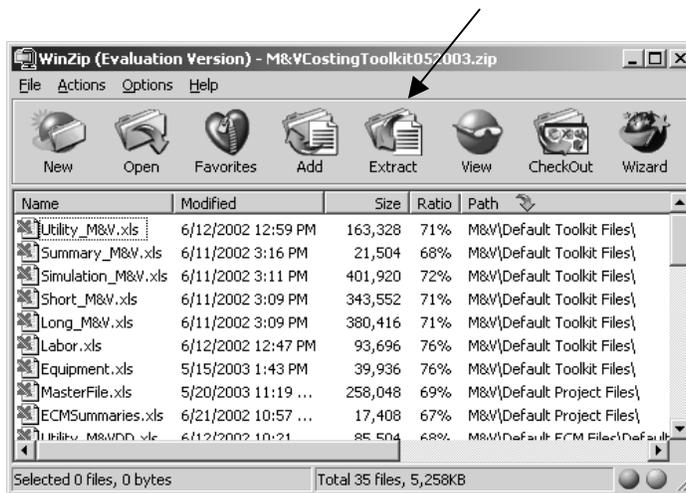


Figure 1. List of zipped files.

3. Using the “Folders/drives” section of the extract form, select the directory to which you would like to install the toolkit. Below the “Files” heading, there should be two options selected: “All files” and “Use folder names”.

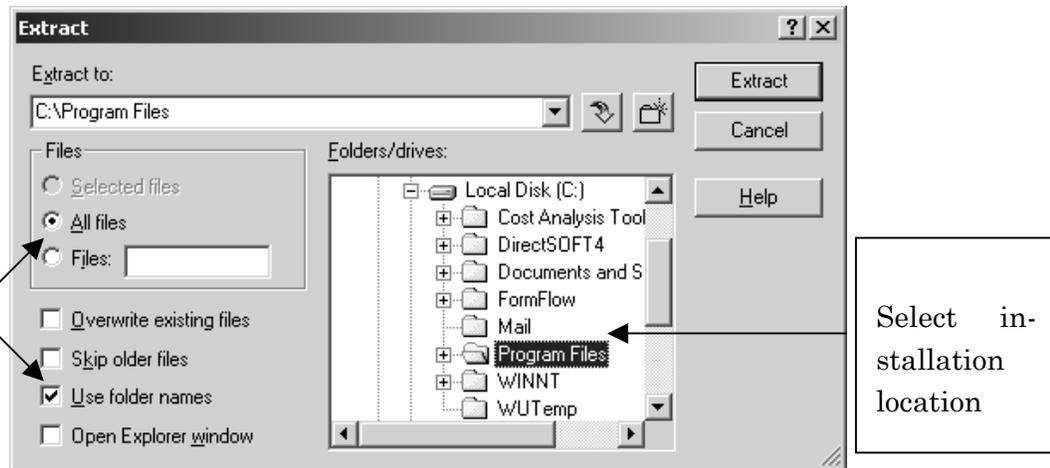


Figure 2. Setting extraction options.

4. Click the “Extract” button on the form to install the toolkit to your selected directory.

After following these four steps, a new folder, “M&V”, will be located in the directory you selected in step 3. For example, if, in step 3, you selected “C:\Program Files”, then after extracting a new directory with the path “C:\Program Files\M&V Toolkit” would exist. The M&V Toolkit folder contains the costing toolkit.

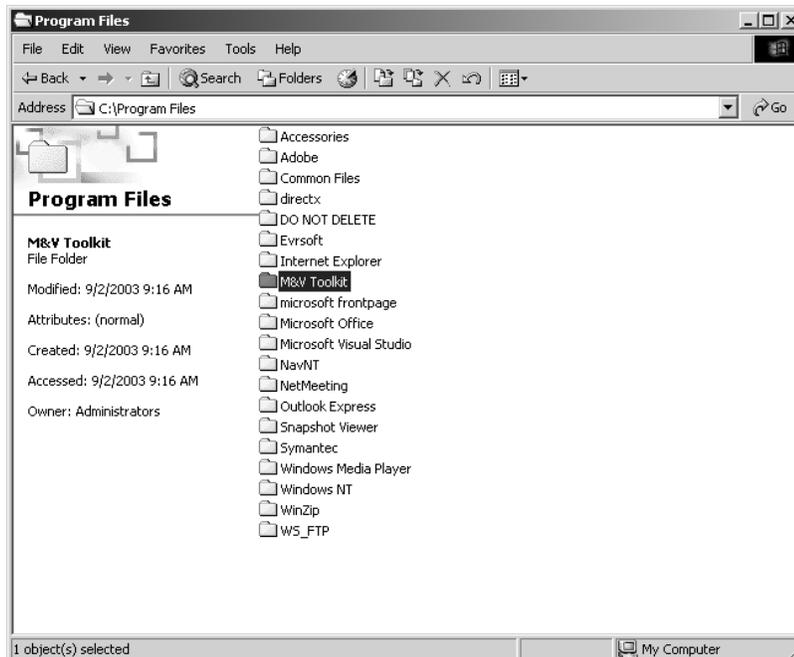


Figure 3. Typical directory tree listing after installation.

## 3 Overview

This section provides an introduction to the main Excel workbooks utilized in the Toolkit. There are four main workbooks/workbook types you will encounter in the toolkit. The first is the M&V Toolkit file found in the root M&V Toolkit folder. From this file you will access the Project Manager, which keeps track of all the ECMs in a project and allows you to add, modify and remove them, as well as enter all the necessary data for a project. From the project manager you will access the other two main workbook types: data input and report workbooks. There are many data input workbooks, all of which look similar. These workbooks are opened from the 'Input Data' button, and allow you to enter various cost data for a project or ECM. There are also several report workbooks, each of which provide an overview of a certain aspect of an ECM or project, giving useful summaries of your project.

The toolkit features cost-estimation tools for four distinct M&V methods: long, short, utility, and simulation. The long m&v method refers to the process of collecting and analyzing data over a period of several years. This method may be more appropriate to use when variations in operations of the facility are expected. The short m&v method refers to the process of collecting and analyzing data over a period of several months. This method may be more appropriate to use when variations in operations are not expected. The utility m&v method refers to collection and analysis of utility bills. If the ECM will have a large impact on the reduction of power consumption, this method is appropriate to use for m&v. Simulation m&v could be used for buildings in which multiple ECMs will be installed or where tracking complex building operation conditions is necessary.

### M&V Toolkit

The M&V Toolkit file is the user-interface of the application. From this file you can create, open and modify, and delete projects. Although transparent to the user, these functions are performed by macros.

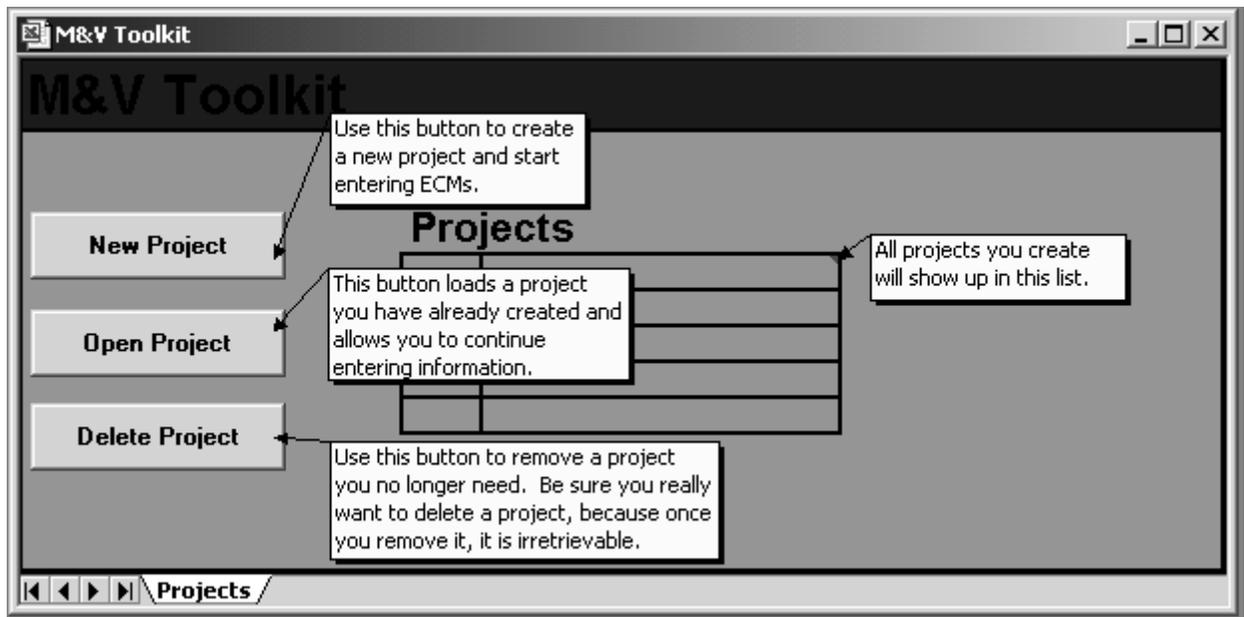


Figure 4. The M&V Toolkit window.

## Project Manager

The project manager is where you will spend the most time in the toolkit. Each project has its own Project Manager. From here you can add or remove ECMs, enter or modify cost data, and compile and view reports for your projects. The files needed to enter or modify data are automatically copied(deleted) to(from) the appropriate directories when you add(remove) ECMs. Similarly, the files needed to compile and view reports are automatically copied to the appropriate directories when you compile reports.

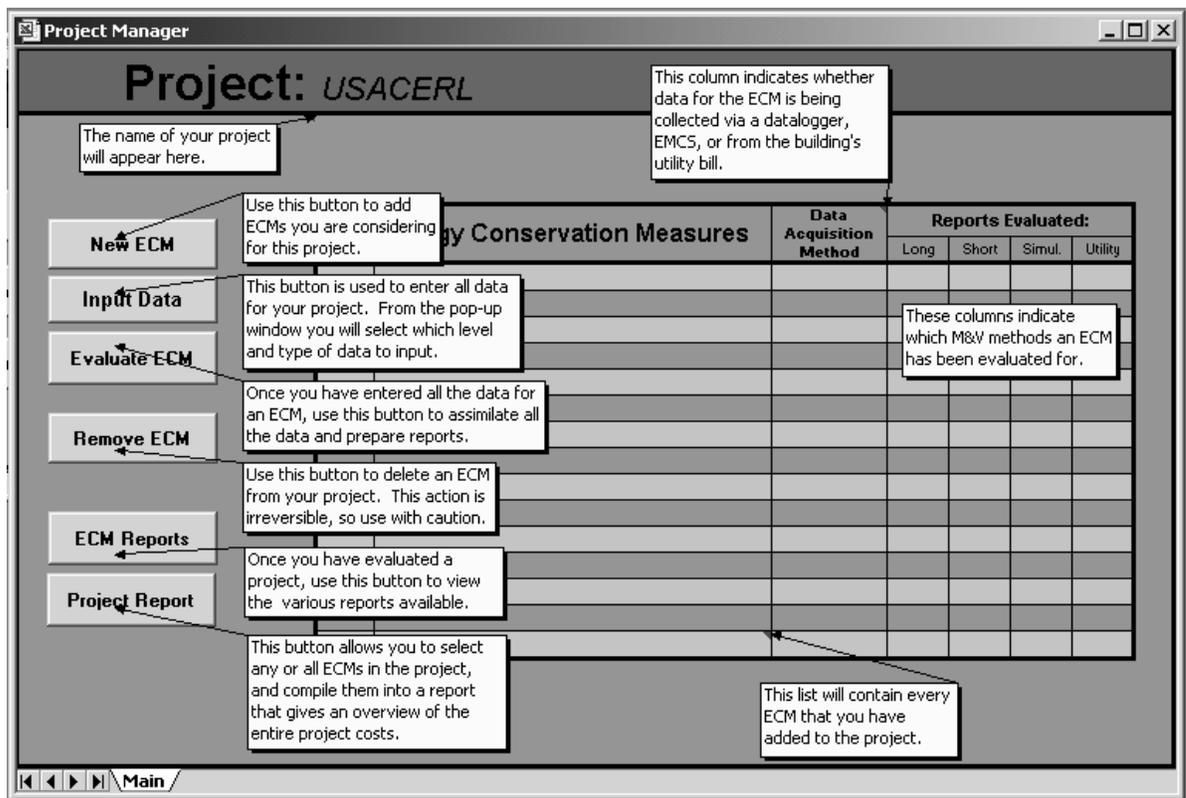


Figure 5. The Project Manager window.

## Data Input

There are five data input workbooks; each allows you to enter certain data for a project. These workbooks are available from the 'Input Data' button in the Project Manager; two of the data input workbooks are specific to the project, and the other two are unique for each ECM in the project. The toolkit manages all these data books through the Project Manager interface. Data can be entered into these workbooks using the 'Input Data' button located in the upper right corner of each sheet.

**DataLoggersDataManipulationCosts** Enter Data

**Data Manipulation Costs: Short M&V - Data Loggers**

No. of Channels: 0  
 No. of Loggers: 0

Polling, QC and Data Entry Costs				
Item	A. Unit	B. Supply		E. No. Per yr
		No. Unit	\$/Unit	
Setup Costs	Per Channel	0	\$0.00	1
Polling Costs	Per Logger	0	\$0.00	52
QC, Database Load	Per Channel	0	\$0.00	52
Data Cleaning	Per Channel	0	\$0.00	1
Computer Maintenance	Per Month	12	\$1.00	12
other		0	\$0.00	0

Ongoing Savings Analysis				
Item	A. Unit	B. Supply		E. No. Per yr
		No. Unit	\$/Unit	
Post-Retrofit Model Costs		4	\$1.00	1
Savings Calculations		4	\$5.00	12
other		0	\$0.00	0

Data Recovery/Missing Data				
Item	A. Unit	B. Supply		E. No. Per yr
		No. Unit	\$/Unit	
Data Recovery	Per Channel	0	\$1.00	1
Missing Data	Per Channel	0	\$1.00	1
other		0	\$0.00	0

Reporting				
Item	A. Unit	B. Supply		E. No. Per yr
		No. Unit	\$/Unit	
Setup Costs		0	\$1.00	1
Report Generation Costs		0	\$1.00	12
other		0	\$0.00	0

One Time Baseline/Post Retrofit Analysis				
Item	A. Unit	B. Supply	E. No.	Per yr

Close-out, Data Transfer				
Item	A. Unit	B. Supply	E. No.	Per yr

Navigation: Long M&V | Short M&V | Simulation M&V

Figure 6. A data input sheet.

### Cost Reports

After an ECM has been created and evaluated, there are various reports available; these can be viewed using the 'ECM Reports' and 'Project Report' buttons on the Project Manager. Which reports are available depends on the Data Acquisition method of the ECM and which M&V methods it has been evaluated for.

<b>Equipment Costs: Long M&amp;V</b>			
Project: CERL			
ECM: Passive Solar HW			
Data Acquisition Method: Data Loggers			
<b>Item</b>	<b>Cost/Item</b>	<b>No. Items</b>	<b>Total Cost</b>
Logic Beach, Inc. - HyperLogger/Power Supply	\$4,093.00	1	\$4,093.00
Istec Corp. (Ista) - 1805-S/G	\$196.00	1	\$196.00
Kele Solutions - SCT-2000	\$137.04	4	\$548.16
The Eppley Laboratory - Model ST-3	\$2,900.00	1	\$2,900.00
<b>Total Cost</b>			<b>\$7,737.16</b>


 \Long M&V / Short M&V / Simulation M&V /

Figure 7. A cost report sheet

## 4 Tutorial

This chapter provides a comprehensive step-by-step tutorial on how to use the toolkit. It guides the user through creating a project, adding ECMs, customizing the data, evaluating reports, and viewing the results.

### Starting Off

To begin using the toolkit, locate the folder in which you installed the application (see chapter 2 for installation instructions). Once you have located the 'M&V Toolkit' folder, double-click the 'M&V Toolkit.xls' file inside.

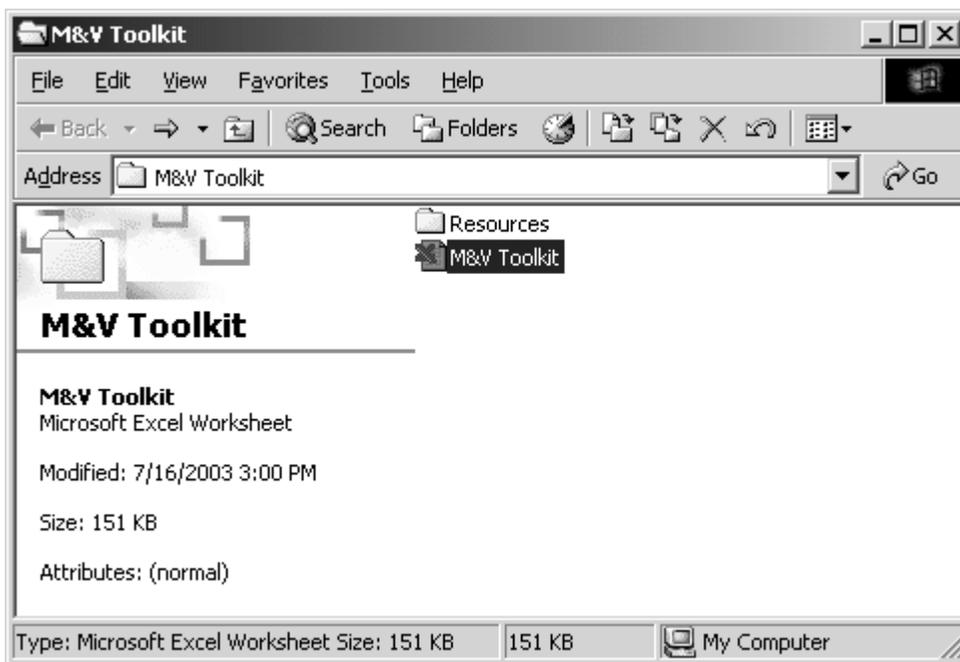


Figure 8. The M&V Toolkit folder

A splash screen will appear, followed by the M&V Toolkit window.

### Creating a New Project

To start a new project, click the 'New Project Button.' A pop-up window will ask you to enter a name for your project. Project names must be longer than one

character and cannot contain the characters \:.\*?<>| or end in a space. Type the name of your project and press 'Create.'

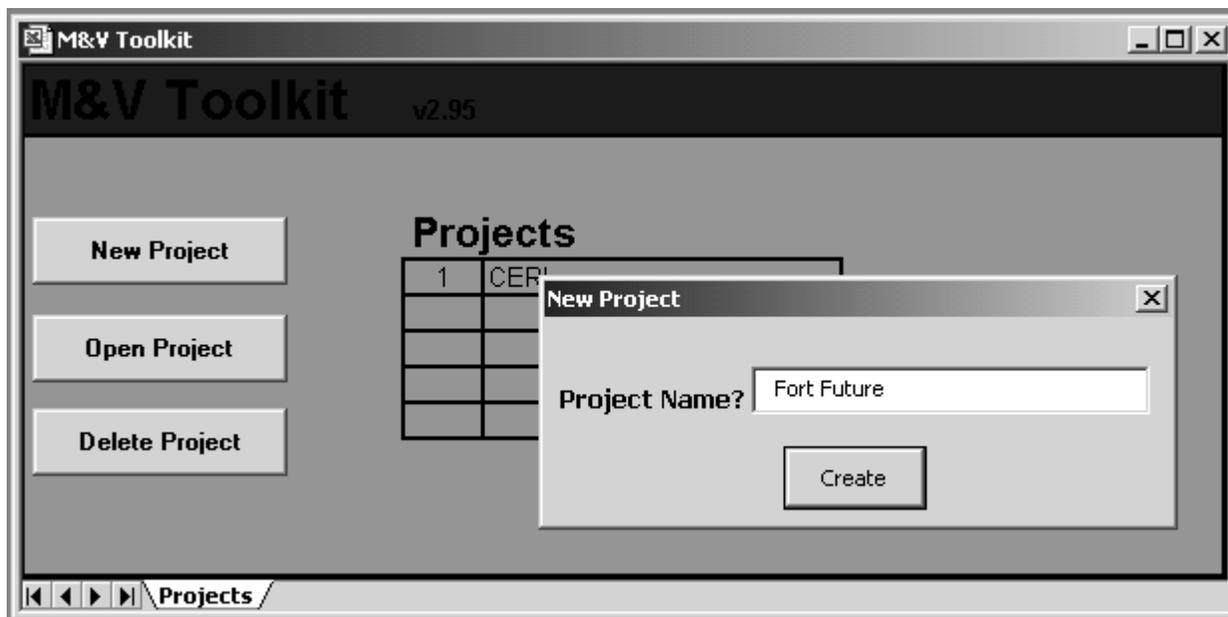


Figure 9. Creating a new project.

The program will copy assorted files to a new project folder and open the Project Manager window, allowing you to begin adding ECMs and data to your project.

## Adding an ECM

To add ECMs to a project, use the 'New ECM' button. This will show a pop-up window that allows you to select an ECM from a dropdown menu or type a custom name for your own ECM (once again, a name cannot contain the characters \:.\*?<>| or end in a space). Here you also select whether data for this ECM will be collected using data loggers, an EMCS, or taken from the building's utility bill. The construction cost of this ECM should also be entered here. This number does not need to be exact; it is used only to estimate M&V cost as a percentage of project construction costs. When you have entered all this information, click 'Create.' Your ECM will now be visible in the ECM list in the Project Manager.

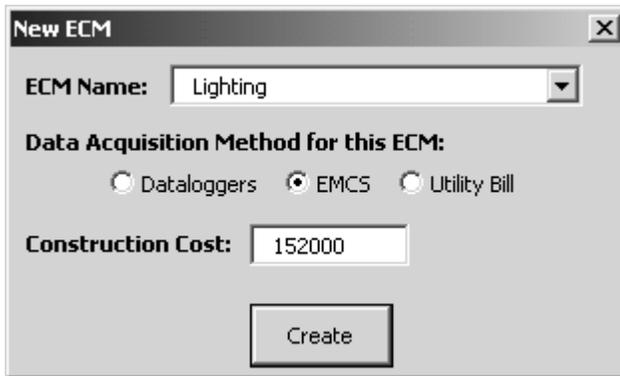


Figure 10. Adding an ECM to a project.

## Entering Project-level Cost Data

To begin entering cost information for your project, click the 'Input Data' button. There are two types of data for a project: project level and ECM level. Project level data is cost information that is the same throughout the project and does not depend on the ECM, method, etc. The Input Data window contains a tree that allows you to select what data you would like to enter. By clicking the '+' next to an item in the tree, you can expand it to bore down to a specific data sheet to complete.

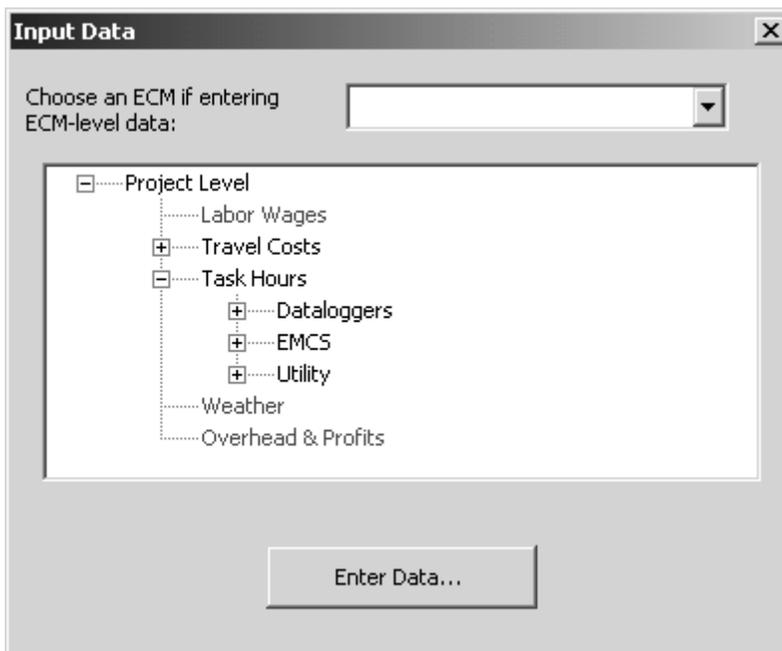


Figure 11. The Input Data window.

If you have not entered data in a certain category, then its name will appear red in the tree. Once you have opened a data sheet, its name will become black.

(NOTE: If you open data sheets but do not save changes when prompted, it will appear that data has been entered in those categories; the program will not function properly if you then evaluate a report without entering data in this category and saving.) There are five types of project level data:

- Labor Wages – a pop-up window allows you to enter hourly wages for all the personnel that will be working on the project. It also lets you enter a fringe benefit percentage that will be added to all employees' wages.

	\$/hr
Project PI	100
Project CoPI	95
Project Manager I	75
Project Engineer	50
Data Base Support Worker	35
Data Base Manager	50
Programming Manager	75
Field Engineer 1	50
Field Engineer 2	35
Data Base Programmer	35
Data Analyst	50

Fringe Benefit % 15.5

Save

**Figure 12. Setting wages for laborers.**

- Travel Costs – this sheet allows you to enter the costs of traveling to the project site to install, maintain, and remove equipment. There are separate data sheets for each method of M&V, allowing you to specify different travel costs depending on the method of M&V of an ECM. The PreMAP Travel costs are those associated with travel to develop a preliminary monitoring and analysis plan. The installation travel cost is associated with the travel needed to install the monitoring equipment. Maintenance travel costs are those associated with travel to maintain equipment. Equipment removal travel cost is associated with the cost of travel to remove equipment at the end of a project. Use the 'Enter Data' button in the upper right to input your numbers. You do not need to enter data for all the methods; only the ones that are going to be used by an ECM in your project.

**Travel Cost Data: Long M&V - EMCS** Enter Data

Installation Travel Costs			
	A. Number of Items	B. Number of People, Days, etc.	C. \$/unit
Transportation	5	1	\$100.00
Lodging - days	5	2	\$100.00
Meals per day	6	5	\$10.00
Misc.	0	0	\$0.00

Maintenance Travel Cost			
	A. Number of Items	B. Number of People, Days, etc.	C. \$/unit
Travel	2	1	\$100.00
Lodging	2	2	\$75.00
Meals	6	2	\$50.00
Misc.	0	0	\$25.00

PreMAP Travel Costs			
	A. Number of Items	B. Number of People, Days, etc.	C. \$/unit
Transportation	5	1	\$100.00
Lodging - days	5	2	\$100.00
Meals per day	6	5	\$10.00
Misc.	0	0	\$0.00

Equipment Removal Travel Cost			
	A. Number of Items	B. Number of People, Days, etc.	C. \$/unit
Transportation	2	4	\$100
Lodging	2	2	\$100
Meals	6	2	\$10
Misc.	0	0	\$16

Navigation: Long M&V / Short M&V / Simulation M&V

Figure 13. The travel cost input data sheet.

- **Task Hours** – these sheets are where you enter the amount of time certain tasks, such as data polling or closeout, will take, and who will be performing the labor. There are different sheets for each data acquisition method and M&V method. Once again, you need only enter data for the combinations that will occur in your project. Once you have opened the desired sheet, use the ‘Enter Data’ button to input your data.

**Task Hours: Long M&V - EMCS** Enter Data

Other Installation Costs				
Item	Units	A. \$/Unit	C. Admin/unit	
			Project PI	
PreMAP		\$0.00	1	12
Parts ordering, etc.		\$0.00	1	20
Other				

**Input Data: Polling, QC and Data Entry Costs**

Setup Costs (Per Channel)	0.5	0.2	Laborer:	Data Base Support Wor
Polling Costs (Per Logger)	0.25	0.1	Administrator:	Project PI
QC Database Load (Per Channel)	0.25	0.1		
Data Clearing (Per Channel)	1	1		
Computer Maintenance (Per Month)	0.25	0.1		
Other	0	0		

Buttons: Done, Cancel

Data Recovery/Missing Data					
Item	A. Unit	C. Labor		D. Admin/unit	
		Project PI		Project PI	
Data Recovery	Per Channel	8	\$40	1	\$16
Missing Data	Per Channel	8	\$40	1	\$16
Other		0		0	

Reporting					
Item	Unit	Labor		Admin/unit	
		Project PI		Project PI	
Setup Costs		2	\$58	1	\$16
Report Generation Costs		0.5	\$58	0.25	\$16
Other		0		0	

Navigation: Long M&V / Short M&V / Simulation M&V

Figure 14. Entering task hours information for an ECM.

- Weather – this pop-up window is where you enter the supply costs, frequency, and labor hours for the collection of weather data necessary to accurately assess the ECM effectiveness. Once you have entered the quantity, supply costs, and frequency of the tasks, click the ‘Labor Hours’ button to enter the amount of time each task will take for the laborer and project administrator.

	Quantity	Supply Cost	Times Per Yr
Setup Costs	1	1	1
Polling/Transfer	1	1	52
QC, Database Load	1	1	52
Data Cleaning	1	1	1
other	0	0	0

Figure 15. Inputting weather data costs.

- Overhead and Profits – this window is where you enter a percentage to accommodate the contractor’s profits and overhead. This number will be multiplied by the entire project cost and added into the final reports.

Figure 16. Setting the contractor's overhead and profits percentage.

## Entering ECM Level Data

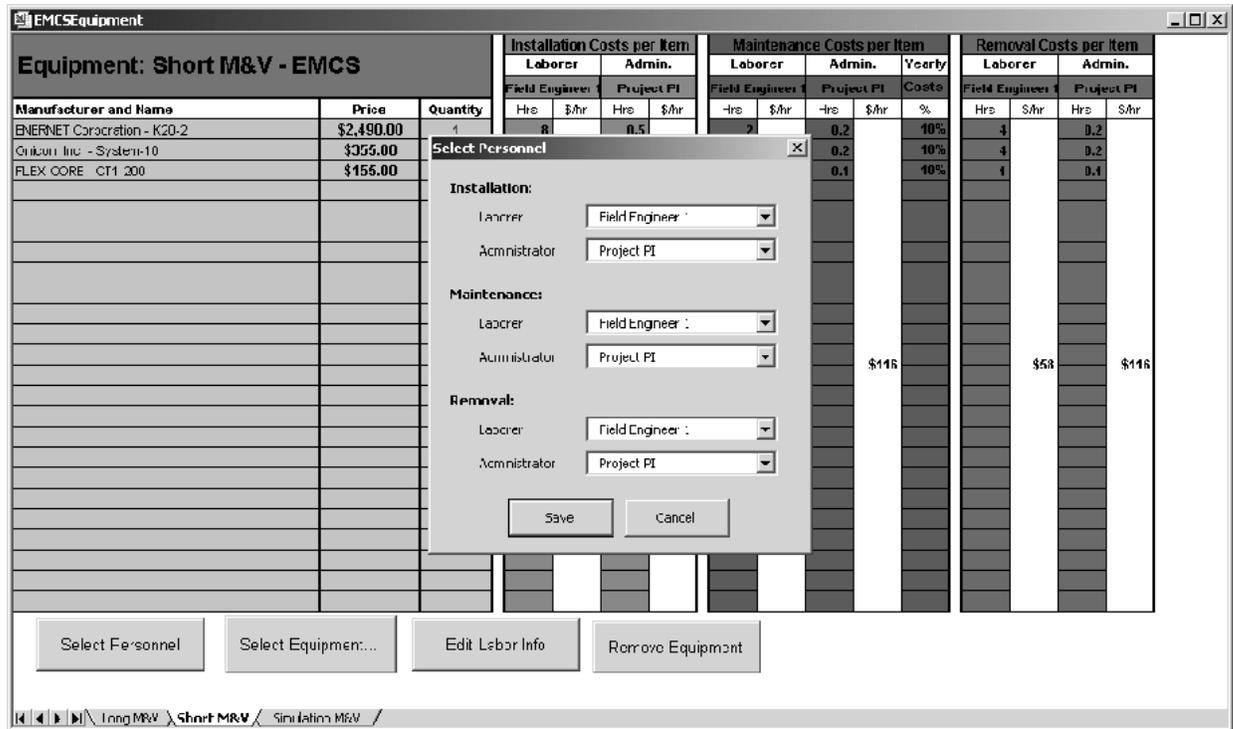
For each ECM you add to your project, you must enter two types of data: equipment and data manipulation costs. You can enter separate equipment lists for the same ECM depending on the M&V method.

Once you have added at least one ECM to your project, click the ‘Input Data’ button. Select the ECM from the dropdown menu at the top, and then expand ECM Level -> Equipment. Click the M&V method that you wish to enter equipment for, and click ‘Enter Data.’

A new worksheet will open, and on this sheet you can enter all the equipment and associated labor you need for your project.

There are four buttons along the bottom of this sheet:

- ‘Select Personnel’ – choose the laborer and administrator who will be handling the installation, maintenance, and removal of your equipment.



**Figure 17. The equipment manager. Here the laborers and administrators for equipment installation, maintenance and removal are being selected.**

- ‘Select Equipment’ – brings up an interface to easily select and add appropriate equipment. Choose the category of equipment you wish to add from the dropdown menu in the upper left. A list of manufacturers will appear in the left pane. Select a manufacturer and a list of models will appear on the right. If you would like details on the model, click the ‘More Info...’ button. When you are satisfied with your equipment choice, enter a quantity in the indicated box and press ‘Add.’

**Select Equipment** [X]

Equipment Type:  
 Portable Logger [v]

Manufacturer:  
 Onset Computer Corporation  
 Logic Beach, Inc.  
 MicroDAQ.com, Ltd.  
 Electricitymetering.com  
 Campbell Scientific, Inc.  
 ACR Systems, Inc.

Model:  
 Versatile 4-Channel Data Logger

[More Info...]

Quantity: 1 [Add] [Cancel]

Figure 18. Choosing equipment for an ECM.

**Equipment Details** [X]



Name: **Versatile 4-Channel Data Logger**  
 Manufacturer: Electricitymetering.com  
 Address:  
 Phone: 877-766-5412  
 403-256-3636  
 Fax: 403-256-3431  
 Web: www.electricitymetering.com  
 Contact:  
 Ext.  
 E-mail: info@electricitymetering.com

Model # MicroDataLogger Data Acquisition System  
 Serial #  
 Characteristics: 4 channels; four universal input/output channels accept both analog and digital  
 Data Resolution: 12 bit digital or 1.2mV analog  
 Accuracy: (analog) +/-0.1% of full scale reading  
 Signal Output: varies by type of measurement  
 Power Requirements: 12 volt DC battery  
 Operating Temp: 32F to 122F  
 Dimensions: 5.8" x 4.4" x 1.6"  
 Description: The MicoDataLogger Data Acquisition System is a battery powered, four-channel data and hand-held meter that records time-series data from virtually any sensor or transducer. The MicroDataLogger Data Acquisition System is a complete monitoring solution for many applications.

Special Requirements:  
 Price: \$645  
 Addtl. Cost 1: \$  
 Addtl. Cost 2: \$  
 Addtl. Cost 3: \$  
 Total Cost: \$645  
 Price as of: 7/1/2003

[Done]

Figure 19. Viewing a detailed description of a piece of equipment.

- ‘Edit Labor Info’ – when you add a piece of equipment to your project, a default set of labor hours is loaded with it. The numbers represent the number of laborer and administrator hours anticipated for each task, and the percentage of the original purchase price allocated each year for maintenance costs. To change these, click the ‘Edit Labor Info’ button, and then select the desired equipment from the dropdown menu. When you are finished, click ‘Save.’

	Hours
<b>Installation:</b>	
Field Engineer 1	2
Project PI	0.5
<b>Maintenance:</b>	
Field Engineer 1	2
Project PI	0.2
Parts costs, etc. (% per year of purchase price)	10
<b>Removal:</b>	
Field Engineer 1	4
Project PI	0.2

Save

Figure 20. Modifying the number of hours allotted for tasks for a piece of equipment.

- ‘Remove Equipment’ – use this button to delete a piece of equipment from your list. The associated labor will also be removed at the same time.

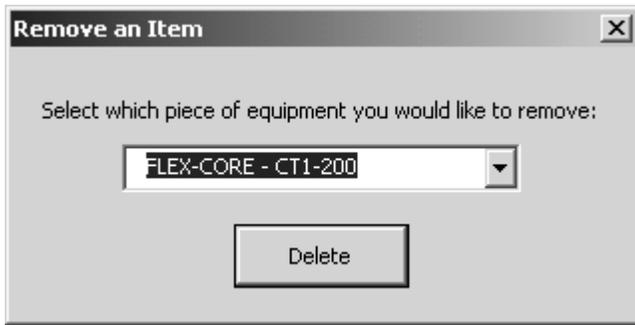


Figure 21. Removing a piece of equipment.

Once you have entered all the equipment for this M&V method of the ECM, save and close the equipment sheet. If you will be evaluating this ECM for more than one method, be sure to enter equipment for each of them.

The final data you need to enter are the Data Manipulation Costs – costs such as data retrieval, lost data recovery, report generation, etc. Expand ‘Data Manipulation Costs’ in the Input Data tree (located under ECM Level) and choose the method you will be evaluating this ECM for (if you will be evaluating for more than one method, repeat the procedure for each). Click ‘Enter Data...’ and use the ‘Enter Data’ button on the worksheet that opens to complete all the data sets.

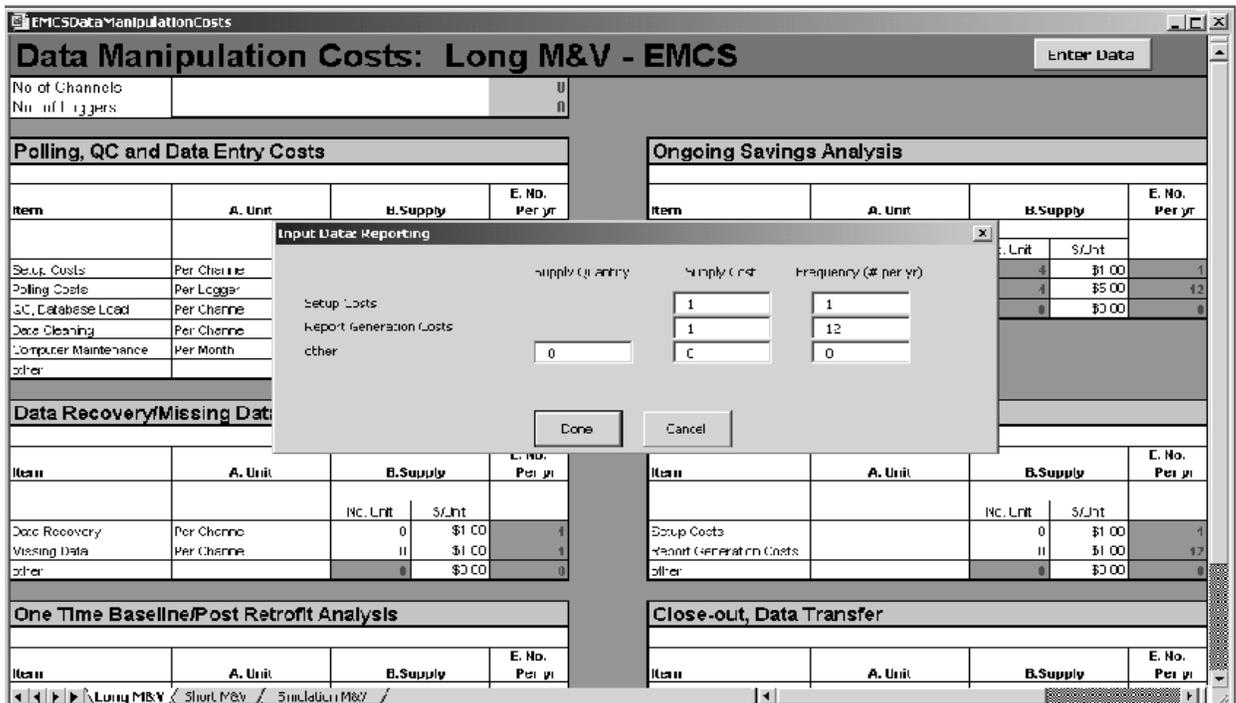
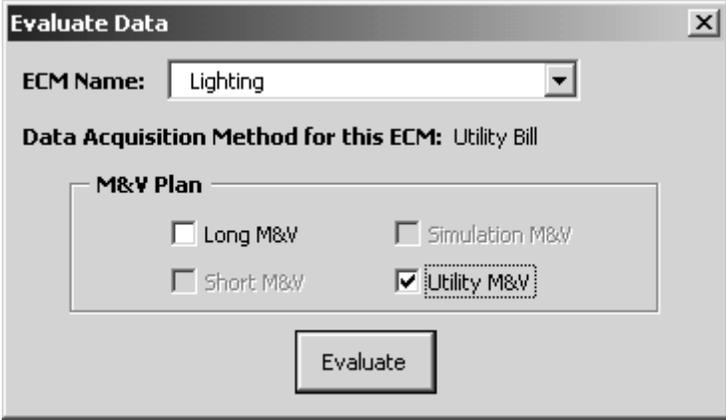


Figure 22. Entering data manipulation costs for an ECM.

Once you have entered in all the data in this worksheet, save and close it. Congratulations, you are now ready to evaluate an ECM!

## Evaluating an ECM

Click the 'Evaluate ECM' button on the Project Manager if you are ready to evaluate. In the following window, select which ECM and M&V method to compile data for, and click the 'Evaluate' button.



The screenshot shows a dialog box titled "Evaluate Data". At the top, there is a close button (X). Below the title bar, the "ECM Name:" is set to "Lighting" in a dropdown menu. Underneath, it says "Data Acquisition Method for this ECM: Utility Bill". A section titled "M&V Plan" contains four checkboxes: "Long M&V" (unchecked), "Short M&V" (unchecked), "Simulation M&V" (unchecked), and "Utility M&V" (checked). At the bottom center of the dialog is an "Evaluate" button.

Figure 23. Evaluate Data window.

If you have not entered all the necessary data, then you will receive a message indicating that something is missing. The input data window will then open. Select the ECM for which you were intending to evaluate, and correct the missing information in the yellow-highlighted fields, then reevaluate.

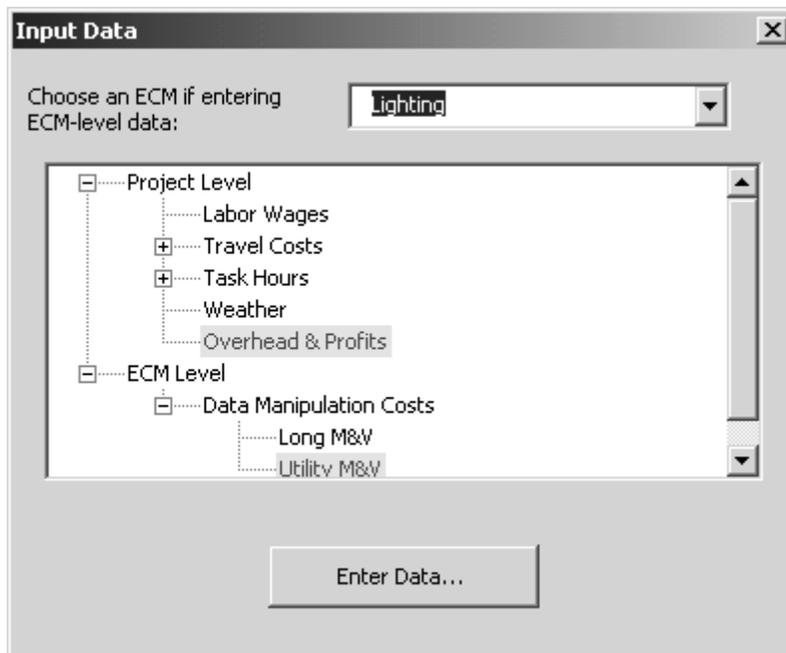


Figure 24. Missing data that must be entered before evaluation.

Evaluation may take several minutes. Please be patient. If evaluation is successful, you will see an x appear in the Project Manager in the row of the ECM, in the column corresponding to the method evaluated.

## Viewing ECM Reports

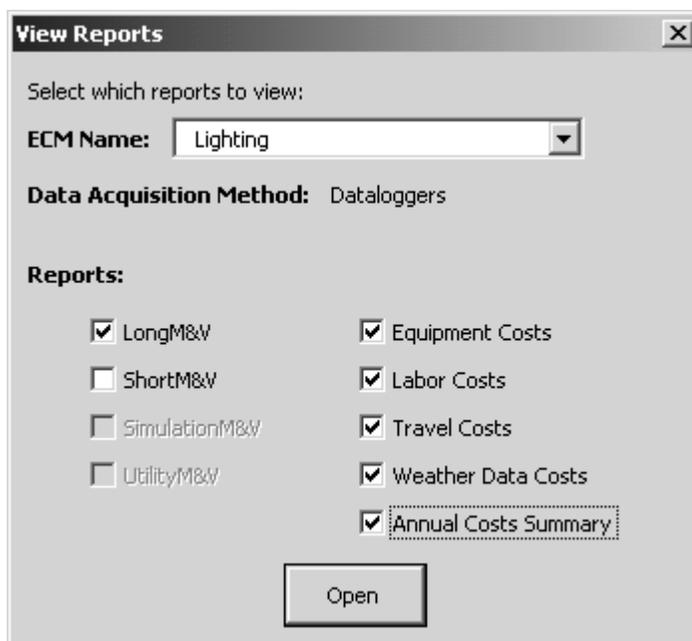


Figure 25. View reports window.

Once you have created an ECM, entered all of the data, and evaluated it, you are ready for your ECM reports. These will give you at-a-glance overviews and detailed summaries of the costs for your ECM. There are 9 possible reports for each ECM – an extensive summary for each method and 5 detailed cost reports:

- Long M&V, Short M&V, Simulation M&V, and Utility M&V – these workbooks each contain two worksheets. The first is a breakdown of costs by category, such as installation, maintenance, savings analysis, or weather data. The second is the raw compilation of all the input data for the M&V method. This sheet contains extensively detailed information on all the costs associated with an ECM.

Cost Summary: Short M&V	
Project: CERL	
ECM: Lighting	
Data Acquisition Method: Data Loggers	
<b>Installation</b>	
Equipment Costs	\$1,808
Labor Costs	\$916
Administration Costs	\$102
Other Installation Costs	\$3,254
Travel Costs	\$3,600
<b>Total</b>	<b>\$9,680</b>
<b>Maintenance</b>	
Equipment Costs	\$181
Labor Costs	\$366
Administration Costs	\$71
Travel Costs	\$1,100
<b>Total</b>	<b>\$1,708</b>
<b>Polling, QC and Data Entry</b>	
Database Setup Costs	\$37
Polling Costs	\$970
QC, Database Load	\$970
Data Cleaning, Data Recovery	\$136
Computer Costs	\$368
Other	\$0
<b>Total</b>	<b>\$2,480</b>
<b>Equipment Removal</b>	

Figure 25. Cost summary by category.

Short-term M&V											
Costing Information for Data Loggers											
0	\$0.00				0	\$0	\$0	\$0	\$0		
0	\$0.00				0	\$0	\$0	\$0	\$0		
<b>Total Costs</b>						<b>\$181</b>	<b>\$258</b>	<b>\$71</b>	<b>\$680</b>		
<b>Maintenance Travel Cost</b>											
	A. Number of Items	B. Number of People, Days, etc.	C. \$/unit	D. Total							
	Travel	2	1	\$100.00	\$200						
	Lodging	2	2	\$75.00	\$300						
	Meals	0	2	\$50.00	\$100						
	Misc.	0	0	\$25.00	\$0						
	<b>Total</b>				<b>\$500</b>						
<b>Polling, QC and Data Entry Costs</b>											
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
		No. Unit	\$/Unit	hrs	\$/hr						
Setup Costs	Per Channel	12	\$0.00	0	\$0	0.2		\$0	\$17	\$20	\$37
Polling Costs	Per Logger	1	\$0.00	0.75	\$0	0.1		\$0	\$44	\$53	\$97
QC, Database Load	Per Channel	12	\$0.00	0.75	\$34	0.1	\$182	\$0	\$44	\$52	\$97
Data Cleaning	Per Channel	12	\$0.00	0	\$0	1		\$0	\$14	\$14	\$28
Computer Maintenance	Per Month	12	\$1.00	0.25	\$0	0.1		\$144	\$32	\$32	\$368
Other		0	\$0.00	0	\$0	0		\$0	\$0	\$0	\$0
<b>Total Costs</b>								<b>\$144</b>	<b>\$104</b>	<b>\$120</b>	<b>\$2,480</b>

Figure 26. Raw compilation of input data.

- Equipment Report – contains the equipment list for the ECM. Use the tabs along the bottom of the workbook to navigate to the M&V method that you wish to view equipment for.

Item	Cost/Item	No. Items	Total Cost
ENERNET Corporation - K20-2	\$2,490.00	1	\$2,490.00
FLEX-CORE - CT1-200	\$155.00	4	\$620.00
The Eppley Laboratory - Model 8-48	\$1,400.00	1	\$1,400.00
<b>Total Cost</b>			<b>\$4,510.00</b>

Figure 27. The Equipment report.

- Labor Report – this report contains laborer and administrator costs for each specific task, and is also broken out by first year, annual, and last year labor costs.

**Labor Costs: Long M&V**  
 Project: CERL  
 ECM: Lighting  
 Data Acquisition Method: Data Loggers

**Year one**

Installation	Field Engineer 1	\$1,017.00
	Project PI	\$116.96
Maintenance	Field Engineer 1	\$406.80
	Project PI	\$81.36
Polling, QC and Data Entry	Data Base Support Worker	\$1,033.95
	Project PI	\$1,301.76
Data Recovery/Missing Data	Data Base Support Worker	\$542.40
	Project PI	\$203.40
One Time Baseline/ Post Retrofit Analysis	Data Analyst	\$452.00
	Project PI	\$152.55
Ongoing Savings Analysis	Data Analyst	\$632.80
	Project PI	\$711.90
Reporting	Data Analyst	\$361.60
	Project PI	\$406.80
<b>TOTAL</b>		<b>\$10,675.68</b>

**Annual**

Maintenance	Field Engineer 1	\$406.80
	Project PI	\$81.36
Polling, QC and Data Entry	Data Base Support Worker	\$1,033.95
	Project PI	\$1,301.76
Data Recovery/Missing Data	Data Base Support Worker	\$542.40
	Project PI	\$203.40
Ongoing Savings Analysis	Data Analyst	\$632.80
	Project PI	\$711.90
Reporting	Data Analyst	\$361.60
	Project PI	\$406.80

Figure 28. Labor cost report.

- Travel Costs – contains a breakdown of travel costs by PreMAP, installation, maintenance, and removal.

**Travel Costs: Long M&V**  
 Project: CERL  
 ECM: Lighting  
 Data Acquisition Method: Data Loggers

**Installation Travel Costs**

	A.# of Items	B.# of People, Days, etc.	C.\$/Unit	D.Total (=AxBxC)
Transportation	5	1	\$100.00	\$500
Lodging days	5	2	\$100.00	\$1,000
Meals per day	6	5	\$10.00	\$300
Misc.	0	0	\$0.00	\$0
<b>Total</b>				<b>\$1,800</b>

**PreMAP Travel Costs**

	A.# of Items	B.# of People, Days, etc.	C.\$/Unit	D.Total (=AxBxC)
Transportation	5	1	\$100.00	\$500
Lodging days	5	2	\$100.00	\$1,000
Meals per day	6	5	\$10.00	\$300
Misc.	0	0	\$0.00	\$0
<b>Total</b>				<b>\$1,800</b>

**Maintenance Travel Cost**

	A.# of Items	B.# of People, Days, etc.	C.\$/Unit	D.Total (=AxBxC)
Travel	2	1	\$100.00	\$200
Lodging	2	2	\$100.00	\$400
Meals	6	2	\$10.00	\$120
Misc.	0	0	\$16.00	\$0
<b>Total</b>				<b>\$720</b>

Figure 29. Travel cost report.

- Weather Costs – gives a line-item overview of the costs of weather data.

<b>Weather Costs</b>	
Project: CERL	
ECM: Cooling Tower VFD	
Hourly Weather Data	
Setup Costs	\$82
Polling Costs	\$1,594
QC, Data Load	\$1,594
Data cleaning, Data Recovery	\$48
Other	\$0
<b>Total</b>	<b>\$3,318</b>

Figure 30. Weather cost report.

- Annual Cost Report – provides a first-year, annual, and last-year cost breakdown of all costs for measurement and verification of an ECM. This is one of the most useful reports, providing a bottom-line M&V cost for the ECM and showing exactly where all the costs come from.

<b>Annual Costs: Long M&amp;V</b>	
Project: CERL	
ECM: Lighting	
Data Acquisition Method: Data Loggers	
No. of years:	5
First Year Costs	Data Loggers
Installation	\$12,498
Maintenance	\$1,939
Polling, QC and Data Entry	\$2,480
Data Recovery/Missing Data	\$770
One Time Baseline/Post-Retrofit Analysis	\$632
Ongoing Savings Analysis	\$1,589
Reporting	\$781
Data Transfer	\$204
Overheads & Profits	\$3,970
<b>Total</b>	<b>\$24,862</b>
Annual Costs	Data Loggers
Maintenance	\$1,939
Polling, QC and Data Entry	\$2,480
Data Recovery/Missing Data	\$770
Ongoing Savings Analysis	\$1,589
Reporting	\$781
Data Transfer	\$204
Overheads & Profits	\$1,475
<b>Total(per year)</b>	<b>\$9,238</b>
Last Year Costs	Data Loggers
Maintenance	\$1,939
Polling, QC and Data Entry	\$2,480

Figure 31. Annual cost report.

## Compiling and Viewing Project Level Reports

Once you have entered all of your ECMs into the project and evaluated them, you may wish to see an overview of your entire project. The 'Project Report' button allows you to select which ECMs to include in your final project report, and

also allows you to choose which M&V option if an ECM has been evaluated for more than one. When you click the 'Project Report' button, a window will open and a list of all the ECMs in your project will be visible. Use the buttons in the middle to add the desired ECMs to the list on the right, then press 'Next.'

You will then see the list of ECMs you chose. Pick the method of M&V you wish to choose for each ECM from the corresponding combo box next to it. If you wish to go back and add or remove ECMs from the report then click 'Back.' If you are satisfied, press 'Compile.'

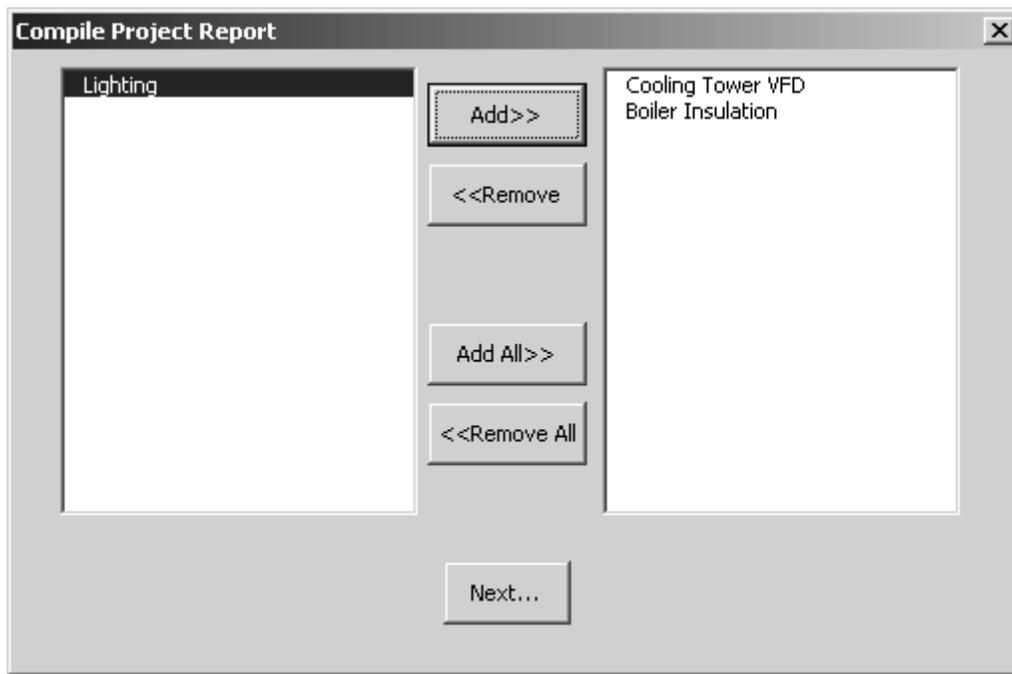


Figure 32. Selecting ECMs to include in the Compile Project Report window.

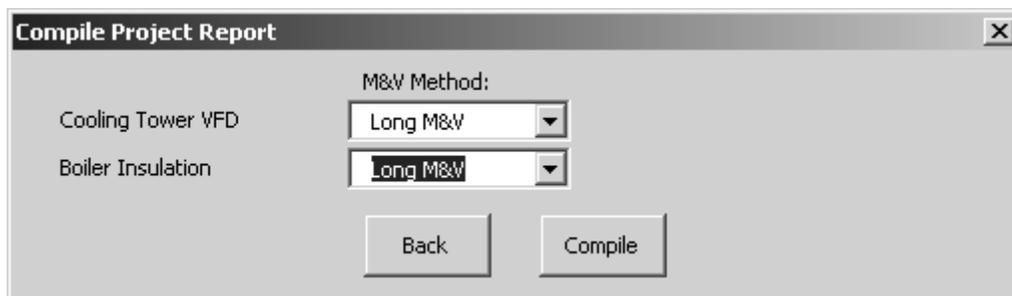


Figure 33. Selecting the M&V method for each ECM in the project report.

Once you have compiled the report (which may take up to a minute or so) it will open. This report workbook contains five worksheets, visible by the tabs at the bottom of the screen.

The first sheet is the Project Summary, which lists each ECM, its M&V cost, the approximate percentage of the construction cost that M&V represents, and the number of years of the contract. It also has these bottom-line numbers for the entire project.

ECM	Data Acquisition Method	M&V Plan	No. Years	Total ECM Cost	Construction Cost	% M&V
Cooling Tower VFD	Dataloggers	Long M&V	3	\$35,454	\$500,000	7.1%
Boiler Insulation	Dataloggers	Long M&V	3	\$29,693	\$246,000	12.1%
<b>SubTotal</b>				<b>\$65,147</b>		
Weather Costs			3	\$11,238		
Travel Costs			3	\$4,320		
<b>Total</b>				<b>\$80,705</b>	<b>\$746,000</b>	<b>10.8%</b>

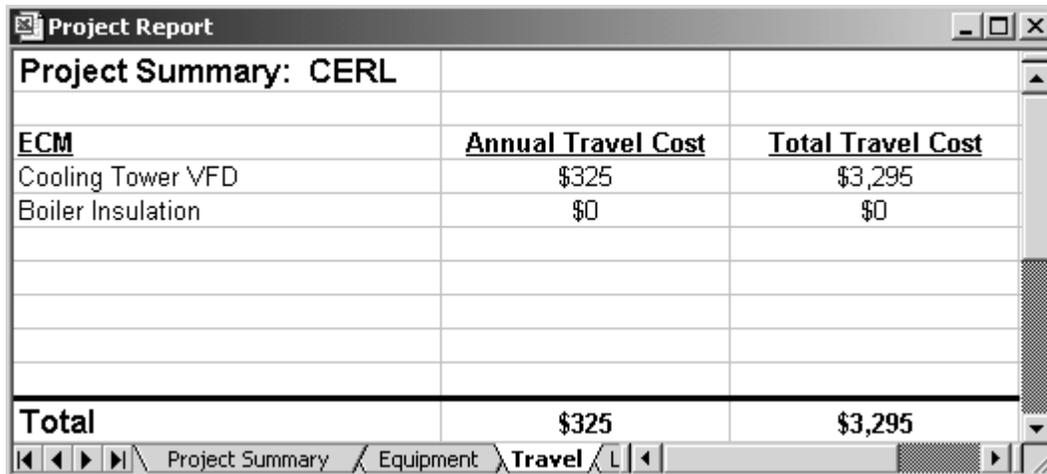
Figure 34. The Project Summary.

The second sheet is the project-level equipment summary; it lists the equipment costs for each ECM.

ECM	Equipment Cost
Cooling Tower VFD	\$645
Boiler Insulation	\$0
<b>Total</b>	<b>\$645</b>

Figure 35. Equipment costs for the entire project.

The third project-level report available is a travel report. It contains a line for the annual costs and total costs related to travel for each ECM, and totals them for the entire project.

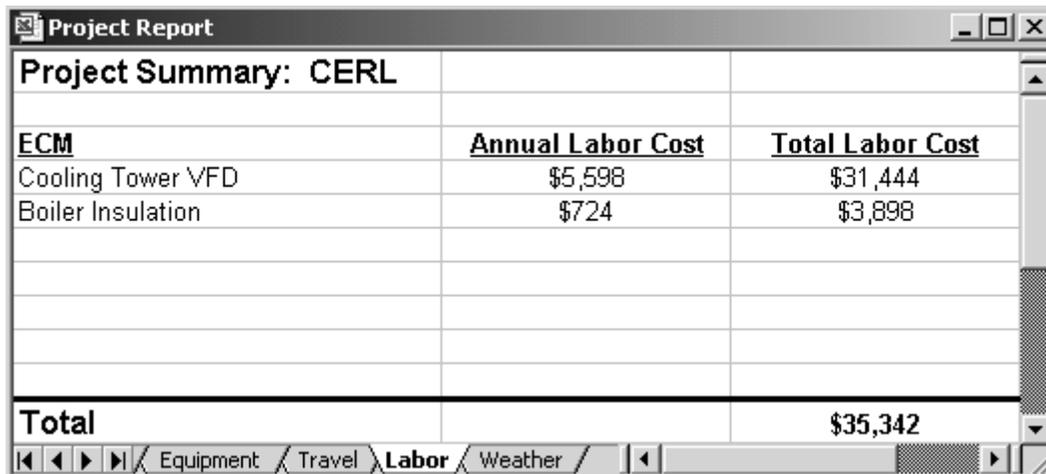


The screenshot shows a window titled "Project Report" with a table of travel costs. The table has three columns: "ECM", "Annual Travel Cost", and "Total Travel Cost". The data rows are: Cooling Tower VFD (\$325 annual, \$3,295 total) and Boiler Insulation (\$0 annual, \$0 total). A "Total" row at the bottom shows \$325 annual and \$3,295 total. The window's navigation bar shows "Travel" is the active sheet.

Project Summary: CERL		
ECM	Annual Travel Cost	Total Travel Cost
Cooling Tower VFD	\$325	\$3,295
Boiler Insulation	\$0	\$0
<b>Total</b>	<b>\$325</b>	<b>\$3,295</b>

Figure 36. The travel costs summary for the whole project.

The next sheet in the Project Report is a Labor report. Once again, this has the annual and total labor costs for each ECM broken out, and the totals for the entire project.

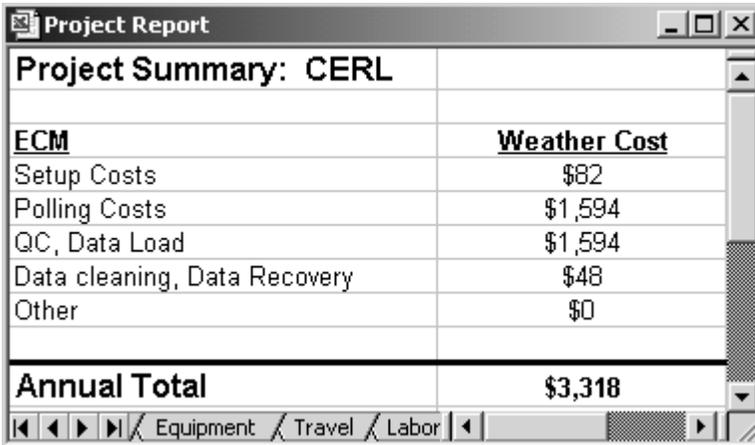


The screenshot shows a window titled "Project Report" with a table of labor costs. The table has three columns: "ECM", "Annual Labor Cost", and "Total Labor Cost". The data rows are: Cooling Tower VFD (\$5,598 annual, \$31,444 total) and Boiler Insulation (\$724 annual, \$3,898 total). A "Total" row at the bottom shows \$35,342 total. The window's navigation bar shows "Labor" is the active sheet.

Project Summary: CERL		
ECM	Annual Labor Cost	Total Labor Cost
Cooling Tower VFD	\$5,598	\$31,444
Boiler Insulation	\$724	\$3,898
<b>Total</b>		<b>\$35,342</b>

Figure 37. The project-level labor report.

The final worksheet in the Project Report workbook is the labor cost summary. This sheet outlines the costs for hourly weather data used to monitor all your ECMs.



<b>Project Summary: CERL</b>	
<b>ECM</b>	<b>Weather Cost</b>
Setup Costs	\$82
Polling Costs	\$1,594
QC, Data Load	\$1,594
Data cleaning, Data Recovery	\$48
Other	\$0
<b>Annual Total</b>	<b>\$3,318</b>

Figure 38. Annual weather costs summary in the Project Report.

## Changing Data

If at some point after creating an ECM and evaluating it, you decide you want to change one or more of the parameters you entered, feel free to do so. Just remember, if you change ECM-level data, you must re-evaluate that ECM. If you change project-level data, all ECMs must be re-evaluated in order for the change to take place.

## 5 Glossary

**annual costs** – labor, equipment, and supply costs that recur every year an ECM is being monitored.

**ASHRAE Guideline 14** – A detailed set of procedures developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers to standardize energy savings measurements and calculations.

**baseline** – the energy or resource usage of a facility before a retrofit. Post-retrofit data is compared to the baseline to determine energy savings.

**DAQ** – Data Acquisition method. This refers to the method of collecting monitoring data for an ECM or project. The toolkit provides three options: using data-loggers, utilizing an existing EMCS panel, or taking data from the utility bill.

**data manipulation** – refers to a set of tasks such as data transfer, missing data recovery, ongoing savings analysis, reporting, and closeout. These tasks are performed for each ECM in the project, and are edited on an individual-ECM basis. This allows the user to specify, for example, monthly reports for one ECM and bimonthly for another in the same project.

**DOE** – Department of Energy.

**ECM** – Energy Conservation Measure. An equipment modification or retrofit, load adjustment, or other measure intended to reduce energy or resource consumption or demand.

**EMCS** – Energy Management and Control System. A networked system of direct digital control capable hardware used to monitor and control building systems, especially HVAC.

**ESCO** – Energy Service Company. A company which provides energy and resource conservation solutions to a facility. The ESCO usually designs and implements ECMs, and in some cases is responsible for maintaining and monitoring the measures.

**FEMP** – The Department of Energy's Federal Energy Management Program works to reduce the cost and environmental impact of the Federal government by advancing energy efficiency and water conservation, promoting the use of distributed and renewable energy, and improving utility management decisions at Federal sites. [taken from the FEMP website, <http://www.eere.energy.gov/femp/>]

**IPMVP** – The International Performance Measurement and Verification Protocol provides an overview of current best practice techniques available for verifying

results of energy efficiency, water efficiency, and renewable energy projects in commercial and industrial facilities. It may also be used by facility operators to assess and improve facility performance. [taken from the IPMVP website, <http://www.ipmvp.org/>]

**M&V** – Measurement and Verification. Specifically, M&V refers to assessing the efficiency improvements delivered by ECMs and verifying that the actual savings correspond to those expected (and often guaranteed by the ESCO).

**M&V Plan** -- For definitions of these methods see the FEMP M&V Guidelines available at <http://www.eere.energy.gov/femp/financing/esp/measguide.html> or call 1-800-DOE-EREC.

**Long** – Collection and analysis of data over a period of several years

**Short** – Collection and analysis of data over a period of several months

**Simulation** – Computer simulation of a building used to estimate a project's energy savings

**Utility** – Analysis of utility bill data to determine energy savings

**macro** – A unit of Visual Basic code that performs a task or tasks automatically. The toolkit invokes many macros to handle input and compilation of cost data in order to simplify the process of estimating M&V costs.

**module** – A collection of one or more Visual Basic macros and functions. Using modules provides additional functionality, allowing a coder to set the scope of variables throughout a project. Modules also allow more organized and easier to follow code.

**PreMAP** – Preliminary Monitoring and Analysis Plan

**retrofit** – A replacement of equipment in a facility often performed to reduce energy consumption or demand. A retrofit usually involves replacing old, outdated equipment with newer, more advanced technology.

**task hours** – A collection of data containing the labor and administration personnel and the number of hours required for several common tasks in a project, such as parts ordering and data manipulation.

**VFD** – Variable Frequency Drive. A VFD controller is used on an electric motor to vary the power supply frequency, which allows the rotational speed of the motor to be controlled. The motor's RPM can be tuned to exactly what is necessary for the current load.

## 6 Formulas and Macros

This section describes in technical detail how the various workbooks in the toolkit interact, and gives a description of the Visual Basic macro code. The bulk of the code is contained within two workbooks: M&V Toolkit.xls, and Project Manager.xls.

### M&V Toolkit.xls

This workbook contains eight code modules. The main modules are described below beginning with the ‘Sheet1(Projects)’ module.

The ‘Sheet1(Projects)’ module contains the main code in this workbook. When one of the three buttons on the Projects worksheet is clicked, the code corresponding to that button in the ‘Sheet1(Projects)’ module is activated. These procedures initialize the user forms and then display the forms to the screen, at which point the code execution switches to the specific form that has been activated.

The ‘projectNameForm’ user form code is responsible for creating a new project. The beginning of the module contains some error handling features. The macro then creates the appropriate directories and copies default files to the new locations.

The ‘openProjectForm’ user form opens the selected project’s Project Manager.xls workbook.

The ‘deleteprojectform’ user form deletes the selected project directory from the M&V Projects folder. The deletion will remove all files and directories associated with the selected project.

The ‘ThisWorkbook’ module contains formatting code to modify the appearance of the worksheet. The ‘ErrorHandling’ module creates an error report if an error occurs during the execution of a macro.

## Project Manager.xls

The heart of the toolkit is the project manager. This workbook contains a number of code modules. The main code, and the interaction among various workbooks, is described below.

The Project Manager has six buttons, each of which triggers a different macro when clicked. Each time a button is clicked, the first thing that happens is that program flow jumps from 'Sheet1(Main)' to the workbook's 'Main' module where public variables are declared and assigned. Next, the form corresponding to the button is activated and shown on the screen. From there, program flow is different for each button.

The first button is the 'New ECM' button. After public variables are declared and assigned by the 'Main' module, execution jumps to the 'NewEcmForm' code, then to the 'SetupNewEcm' module. The code copies the appropriate files to the proper directories and adds the ECM to the list in the Project Manager.

The second button is the 'Input Data' button. After public variables are declared and assigned by the 'Main' module, execution jumps to the 'InputDataForm' code, then to the 'InputData' module. The code opens the appropriate workbook based on the user's selection on the input data form.

The third button is the 'Evaluate ECM' button. After public variables are declared and assigned by the 'Main' module, execution jumps to the 'EvaluateForm' code, then to the 'GetWorkbooks' module, then to the 'Evaluation' module. The code first assimilates all of the data input by the user into a single summary workbook (which workbook depends on the M&V method and data acquisition method). Next, the macro disseminates the data from the summary book to several useful reports. All of the data manipulation is done using named ranges in the Excel worksheets.

The fourth button is the 'Remove ECM' button. After public variables are declared and assigned by the 'Main' module, execution jumps to the 'RemoveEcmForm' code. The macro permanently deletes all of the ECM level data associated with the selected ECM.

The fifth button is the 'ECM Reports' button. After public variables are declared and assigned by the 'Main' module, execution jumps to the 'ReportForm' code, then to the 'ViewReports' module. The macro opens the selected report(s).

The sixth button is the 'ProjectReports' button. Once again, after public variables are declared and assigned by the 'Main' module, execution jumps to the 'CompProjRep' code, then to the 'GetProjWorkbooks' module, then to the 'ProjectEvaluation' module. The macro dynamically calculates the cost of a project based upon the selected ECMs and the length of time they each will be monitored. Following this, the macro copies these costs into the Project Report workbook, yielding a concise summary of the project.

Additional code that provides visual and practical enhancements is located in the 'ErrorHandling' module, the 'Formatting' module, the 'Navigation' module, the 'TreeNodes' module, and the 'ThisWorkbook' module. The 'ErrorHandling' macro is called when a runtime error occurs during execution in the toolkit. The macro creates a time-stamped entry in an error log file and displays a message to the user advising them that an error has occurred. The 'Navigation' module creates and dynamically updates a menu in the 'Window' menu at the top of the screen. This menu allows a user to activate any available report for a project if that report is open. The 'TreeNodes' module is called every time the input data window is shown, and it is responsible for populating the list of data to input and color-coding the entries. This module works off of a hidden matrix in the Project Manager file that keeps track of all the ECMs and what data has been entered. The 'ThisWorkbook' code contains maintenance functions that run on the opening and closing of the Project manager