SUSTN-106 Course

MILWAUKEE AREA TECHNICAL COLLEGE
TECHNICAL AND APPLIED SCIENCES (MATC/T&AS)

Sustainable Facilities Operations Program

SUSTN-106 Measurement and Verification

National Science Foundation - National Center for Building Technician Education

2014-06-01

Course Documentation

This material is based upon work supported by the National Science Foundation under Grant Number (DUE 1204930).

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Technical and Applied Sciences Department
6665 South Howell Avenue
Oak Creek, WI 53154
Phone 414.571.4570

Table of Contents

Catalog description

This course covers different methods of measuring and verifying energy savings. Emphasis is on the International Performance Measurement & Verification Protocols (IPMVP) and includes hands on measurement and verification (M&V) using kWh meters, energy management systems, and data loggers. Information covered will prepare the learner to take the national certification exam for measurement and verification. All energy managers know the importance of verifying that projects are working, including promoting success within and outside organizations. This course covers the simple to complex methodologies for measuring success so that systems and projects are documented and managed.

Class hours

24 hours of lecture and 24 hours of self-directed research.

Self-directed research is part of each homework assignment, see sample in Appendix C.

Units

3 Credits

Entry skills needed

The following are required for admission to the course:

- A high school diploma or GED
- Demonstration of proficiency in basic skills through a course placement assessment
- Course requires computer skills in word processing, spreadsheets, and Power Point.

In addition, the potential for success in the program will be enhanced if students have:

- Work experience
- Familiarity with building energy using systems (lighting and mechanical)
- A strong interest in sustainability and facilities management
- Critical thinking and problem-solving skills
- And have organizational skills.

Syllabus

See Appendix A for sample syllabus with course schedule and policies.

Student learning outcomes

The exit skills listed in the next section support these three learning outcomes:

Learn the IPMVP process for M&V projects

Students understands the process of M&V by learning IPMVP, in particular the different M&V options.

Able to use data loggers and other M&V equipment / meters

The student uses different types of equipment during the class:

1. Spot measurements (digital light meter, plug load meter, utility meters, BAS),
2. Accumulating meter (plug load meter, T&RH Logger, utility meters, BAS),
3. Data logging equipment/software (T&RH logger, BAS)
4. Utility grade meters: gas, water and electric at home or work

Data analysis

Student can use the data collected for analyzing loads and energy use of equipment, relating it to the IPMVP process.

Exit skills

Course content to achieve student learning outcomes:

1. Student is able to download the required version of IPMVP, Volume 1
2. Student understands that IPMVP is a voluntary guideline, not a code.
3. Student can describe the benefits of using the IPMVP.
4. Student can list potential uses and users of IPMVP
5. Student can describe the need for an M&V plan.
6. Student can describe what a baseline case.
7. Student can describe the reporting period.
8. Student can list and describe the four IPMVP Options.
9. Student can articulate what persistence of savings means.
10. Student is able to read utility grade meters:
    a. Water
    b. Gas
    c. Electric

11. Student is able to correlate the reading from a utility grade meter to the proper units (CCF, therm, gallon, kWh, kW, and btu) and billing data.
12. Student is able to take multiple readings and determine consumption from utility grade meters.
13. Student is able to correlate the utility meter readings to the uses and loads served by that meter over different lengths of time and relative to variables such as weather.
14. Student is able to take spot measurements and apply the data, understanding limitations for extrapolating to longer term loads.
15. Student can differentiate between spot, accumulating, and data logging equipment.
16. Student can set up and down load data from data loggers.
17. Student can analyze data by using calculations and graphing techniques.

Course materials

Principal text

International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings - Volume I EVO 10000 - 1:2012 http://www.evo-world.org/

Lecture materials and handouts

Refer to Appendix B for an example

- Presentations (PowerPoint):
    - SUSTN106 IPMVP 2012 CH01 Introduction to IPMVP.pptx
    - SUSTN106 IPMVP 2012 CH02 Definition and Purposes of MV IPMVP 2012.pptx
    - SUSTN106 IPMVP 2012 CH03 Principles of M&V.pptx
    - SUSTN106 IPMVP 2012 CH04 Framework and Options a.pptx
    - SUSTN106 IPMVP 2012 CH05 M&V Plan.pptx
    - SUSTN106 IPMVP 2012 CH06 M&V Reporting.pptx
    - SUSTN106 IPMVP 2012 CH07 Adherence with IPMVP.pptx
    - SUSTN106 IPMVP 2012 CH08 Common M&V Issues.pptx
    - Gas Electric Meter Reading.pptx
    - Determining Utility Rate from billing.pptx
    - Lighting Measurements IES.pptx
    - Utility Bill Discussion.pptx

Other reference materials

None

Software required

Access to computer with:

- Microsoft Office Programs (Word, Excel, PowerPoint, etc.).
- Adobe Reader (for pdfs). Price: Free. Source: www.adobe.com.
- Access to computer with internet access. (i.e. Internet Explorer, Mozilla Firefox, Safari, etc.).
- Data Logger Software (in this case BoxCar from Onset Computer)

Lab setup and materials

None needed.

Equipment & instruments required

- Hobo T&RH Data Logger
- Kill-A-Watt meter
- Light Meter

Available at MATC South Library for the duration of the course

Assessment

Methods

- Reviews: These are "tests" taken in Blackboard that are simply going over the reading material for that week. It is assumed that the student reads the items first.
- Homework: Presented in BlackBoard and summarized in Appendix C.
- Class Participation: There are activities, such as programming and downloading data from T&RH loggers. If you are not in class when that item is submitted, there is no making it up.

Sample test questions

There are seven quizzes for this course:

1. CH01 IPMVP 2012
2. CH02 IPMVP 2012
3. CH03 IPMVP 2012
4. CH04 IPMVP 2012 01
5. CH04 IPMVP 2012 02
6. CH05 IPMVP 2012
7. CH06 IPMVP 2012

Refer to Appendix D for an example

Sample of weekly assignments

There are five assignments for this course spread over the 8 week period. Refer to Appendix C for an example

Listing of homework for class:

- HW01 Utility Meter Readings
- HW02 Utility Meter Readings Log
- HW03 Kill-A-Watt, using the meter
- HW04 Kill-A-Watt Long Term Metering

- HW05 T&RH Data Logger and Analysis

Project

Not at this time because it was very difficult to get in 8 weeks. However, the course was originally set up with a project which MATC may bring back in 2015 when the course goes to 16 weeks.

The project was for the student to define an M&V project, set up a project plan, conduct the baseline measurement, reporting period measurement, conduct analysis of data, and write an M&V report - all done following the IPMVP guidelines.

Adaptability to on-line format

This course should not be delivered on-line due to required work. While it could be possible, the metering and data equipment students use from the library do have software and download cables that would be costly to have available in the quantity needed for an entire class.

Currently the entire course is in BlackBoard online but taught in lecture / discussion /lab format. Test is online. All homework is available online.

Appendix A – Sample Syllabus

Course Syllabus – SUSTN-106-600 Measurement and Verification

MILWAUKEE AREA TECHNICAL COLLEGE
Course Syllabus

Spring, 2014

Course: *Measurement and Verification*		**Credits:** *3*
Subject Abbreviation: SUSTN	**Course Number:** 106	**Section Number:** 600
Class Meets: *In E114b Tuesdays, 5:45 PM to 8:40 PM in room #E114b: Jan 28th – March 18th, 2013*		
Instructor: *Ted Wilinski*		
Office: *E108*	**Office Hours:** *The hour before class in either E108 or E114b*	
Phone number: *(414) 571-4570*	**E-mail:***wilinskt@matc.edu*	

Course Description: *This course covers different methods of measuring and verifying energy savings. Emphasis is on the International Performance Measurement & Verification Protocols (IPMVP) and includes hands on M&V using kWh meters, energy management systems, and data loggers. Information covered will prepare the learner to take the national certification exam for measurement and verification. All energy managers know the importance of verifying that projects are working, including promoting success within and outside organizations. This course covers the simple to complex methodologies for measuring success so that systems and projects are documented and managed.*

Prerequisites: *None*

ADA Statement:
If you have a disability that impacts your classroom performance and wish to request an accommodation, contact the Office of Student Accommodations (414)297-6838. They may require documentation regarding your disability to enable them to comply with your request. Admission of a disability is voluntary and will be handled in a confidential manner. MATC does not discriminate against individuals with disabilities and fully complies with the Americans with Disabilities Act.

To ensure your academic success in this program, you are strongly encouraged to provide your instructor with a copy of the Instructor Notification Form from the Office of Student Accommodations. This should be done at the beginning of the semester.

Textbook(s): *International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings - Volume I EVO 10000 - 1:2012*
http://www.evo-world.org/index.php?option=com_content&view=article&id=272&Itemid=504&lang=en
PLEASE NOTE: In the event that the MATC book store does not carry any of the above texts, students may purchase their copies through the online vendors or book stores of their choice.
Supplies: *Hobo T&RH Data Logger and Kill-A-Watt meter – available at MATC South Library for the duration of the course*

Attendance Policy: **Miss first two classes and you are automatically withdrawn from the class!**
Attendance will be taken on a daily basis. Students are expected to attend class regularly and to arrive on time. It is the student's responsibility to discuss absences with the instructor and follow up with an email. No email, no consideration for an excused absence. When an absence occurs, the student is responsible for making up the work. Work can be found in Blackboard. As a general rule, no exceptions for not meeting due dates are given for being absent. If there is an exception, it has to be detailed in a response from the instructor to your email explaining the absence. Miss 4 classes and you will be withdrawn from the course.

Tests/Assignments Make-up Policy:
It is the responsibility of the student to keep track of work and grades. In Blackboard, the "MyGrades" tab can be very helpful to check on completed work and view your grades. Ignorance of not knowing an item was due is not an excuse.

Any late work will have 5% taken off for each day it is late. For instance, a chapter review done the morning of class will be considered one day late. Five percent will be taken off the score. So, if a score of 13 points out of 15 is awarded for that chapter review, then 13/15= .867 or 86.7%. Five percent will be taken off, or 87%-5% = 81.7% for a final score.

Any item over two weeks late is not accepted and the student will receive a zero for that grade.

There can be extenuating circumstances but these have to be discussed and agreed upon in writing by both parties at the time the work is due, not after the two week period.

Assessment Activities: note: assessment activities are subject to change as the semester progresses.

- **Test:** *These are "tests" taken in Blackboard that are simply going over the reading material for that week and covering items from lectures/class. It is assumed that the student reads the chapter first. Refer to Blackboard for details.*
- **Homework:** *There are several homework items that are assigned during the semester to help with understanding of the course materials. Refer to Blackboard for details.*
- **Class Participation:** *There are activities, such a question answered the first minute of class (and handed in right away) that are part of each class. If you are not in class when that item is submitted, there is no making it up.*

Grading Standards: note: grading standards are subject to change as the semester progresses.

- **35% Test:** *Typically each test or Chapter Review is weighted the same.*
- **50% Homework:** *Typically each Homework is weighted the same.*
- **15% Class Participation:** *There will be various activities each day in class that require you to submit work in class. If you are not there, late or leave early there is no opportunity to make it up. See Blackboard and listen first day of class for more details.*

Refer to Blackboard for details.

Grading scale is as follows:

A	4.00 Superior	for grades between 94% and 100%
A-	3.75	for grades between 90% and less than 94%
B+	3.25 Above Average	for grades between 87% and less than 90%
B	3.00	for grades between 84% and less than 87%
B-	2.75	for grades between 80% and less than 84%
C+	2.25 Average	for grades between 77% and less than 80%
C	2.00	for grades between 74% and less than 77%
C-	1.75	for grades between 70% and less than 74%
D+	1.25 Below Average	for grades between 67% and less than 70%
D	1.00	for grades between 64% and less than 67%
D-	0.75	for grades between 60% and less than 64%
U	0.00 Unsatisfactory/Failing	for grades less than 60%

Instructor Support: Students are encouraged to contact the instructor before or after class, and during office hours, if they have questions or problems related to the class. It is suggested that students contact the instructor immediately in order to avoid falling behind in class. Please do not wait until the end of the semester to discuss issues that should have been resolved much earlier.

Academic Support Services: In addition to obtaining course-related assistance from the instructor, students may obtain assistance from the Academic Support Centers located at the Milwaukee, North, South, and West campuses. These centers are open to all MATC students. Services include, but are not limited to, assistance in computer applications, course assignments, Internet use, math, science, social studies, study skills, and writing. Please call the Academic Support Center at your campus for more information.

Instructor Recommended Withdrawals: You may be dropped for absenteeism when:

1. You are absent three consecutive classes.
2. Your attendance is sporadic (e.g., you miss three class periods), and you are unable to make up the instruction missed.
3. You fail to meet attendance requirements of licensing agencies.
4. You pose a safety hazard to yourself or others because of missed instruction critical to safe class or lab performance.
5. You are unable to make up instruction missed in a lab/shop class.
6. You have not attended class during the first two weeks of the term.

Dropping or Changing Courses: Students who are considering dropping the course should first discuss this with their instructor, counselor, or faculty advisor before dropping. They may be able to recommend an alternative course of action. Please be aware that dropping a course could result in a student being placed on warning or suspension at the end of the semester. Also, please be aware that dropping a course does not mean you will be refunded.

Students who wish to drop a course may voluntarily withdraw from the course up to two weeks before the last day of the semester. Course Change forms are available in the Registration office at the Milwaukee Campus or in Student Services at

the regional campuses. Students who do not report for the final examination (or presentation) and does not formally withdraw nor arrange for an incomplete grade, will be given a U grade for the course.
Incompletes: A grade of Incomplete may be granted, at the discretion of the instructor, in cases where the student has completed at least 75% of the course with a C or better at the time the Incomplete is requested. Students must complete the missing work within one semester or else the Incomplete grade will revert to a U.
Student Complaint Procedure: MATC has established a formal system to assist students in resolving academic problems and course-related issues. In order for a complaint to be valid, the following steps must be followed in order: Step 1: Meet with the instructor to discuss any questions related to the course (e.g., requirements or assignments) or if you are experiencing academic problems. If the issue is unresolved after meeting with the instructor, Step 2: Meet with the associate dean of the department. If the issue is unresolved after meeting with the associate dean, Step 3: Meet with the dean of the department. If the issue is unresolved after meeting with the dean, Step 4: Go to the Office of Student Life for assistance.
Retention Alert: MATC is interested in the success of all of its students. Retention Alert is a tool that instructors, along with the counseling and advising department, use to help improve student success. There are three areas of Retention Alert: financial, personal/confidential, and retention. Retention Alert is designed to identify students who may be at risk of academic difficulty or failure as early as possible. Throughout the semester, an instructor may create Retention Alerts or referrals for some of their students. After a referral is made, the student will be contacted by someone by phone or email to discuss resources or set up an appointment to meet in person. The Retention staff follows up with the student and the student's instructor to facilitate support efforts. Prevention and intervention are key with students so timing and resources are important. With Retention Alert, hopefully students can get the help they need, when they need it.
OTHER IMPORTANT INFORMATION: No cell phones, no texting, no ear buds or other head phone set up, no computers. Please refer to the links in Blackboard under the "Syllabus" tab. Those links are: • Student Code of Conduct • Student Accommodation Services • Student Handbook

5:45 PM to 8:40 PM | **SUSTN106 M&V** | Updated 03/11/14

Room E114b | CALENDAR | Spring Semester 2014

WEEK 01 — **JANUARY 28**

- THIS WEEKS TOPICS :
  1. Chapter 1: Introduction to IPMVP
- DUE MONDAY NIGHT:
  1. Nothing Due This Week – class did not start
- In Class Participation:
  1. Sign Syllabus Receipt Form and turn into instructor
  2. Look at MATC gas and electric meters
  3. Get and set up data loggers

WEEK 02 — **FEBRUARY 4**

- THIS WEEKS TOPICS :
  1. Chapter 2: Def & Purposes of M&V
- DUE MONDAY NIGHT:
  1. Chapter Reviews: 1 & 2
- In Class Participation:
  1. Before Class – download data loggers
  2. Before Class – download IPMVP book as described in BlackBoard
  3. Items from Week one since "snow day"

WEEK 03 — **FEBRUARY 11**

- THIS WEEKS TOPICS :
  1. Chapter 3: Principles of M&V
- DUE MONDAY NIGHT:
  1. Chapter Reviews: 3
  2. HW01
- In Class Participation:
  1. CP Quiz?
  2. Discuss homework and chapter reviews (Test)?

WEEK 04 — **FEBRUARY 18**

- THIS WEEKS TOPICS :
  1. Chapter 4: IPMVP Framework & Opts
- DUE MONDAY NIGHT:
  1. HW03
- In Class Participation:
  1. CP Quiz?
  2. Discuss homework and chapter reviews (Test)?

WEEK 05 — **FEBRUARY 25**

- THIS WEEKS TOPICS :
  1. Other lectures
- DUE MONDAY NIGHT:
  1. Chapter Reviews: 4 part 01
  2. Preliminary HW02
  3. HW04
- In Class Participation:
  1. CP Quiz?
  2. Discuss homework and chapter reviews (Test)?

NOTE: Calendar is subject to change *and will*. Items may be modified, added or deleted.
Keep looking at BlackBoard in the Calendar Tab for the most up-to-date Calendar

Office hours are before and after class 1 *Absences must be documented with an email to the instructor*

5:45 PM to 8:40 PM | **SUSTN106 M&V** | Updated 03/11/14

Room E114b | CALENDAR | Spring Semester 2014

WEEK 06 **MARCH 4**

- THIS WEEKS TOPICS :
  1. Data Logger Discussion
  2. Chapter 5: M&V Plan Contents
- DUE LATER IN WEEK:
  1. Chapter Reviews: 4 part 2
  2. Chapter Reviews: 5
- In Class Participation:
  1. CP Quiz?
  2. Discuss homework and chapter reviews (Test)?

WEEK 07 **MARCH 11**

- THIS WEEKS TOPICS :
  1. Chapter 6: M&V Reporting
  2. Chapter 7: Adherence with IPMVP
- DUE MONDAY NIGHT:
  1. Chapter Reviews: 6
  2. ~~Chapter Reviews: 7~~
  3. HW02 & HW05a
- In Class Participation:
  1. CP Quiz?
  2. Discuss homework and chapter reviews (Test)?

WEEK 08 **MARCH 18**

- THIS WEEKS TOPICS :
  1. Chapter 8: Common M&V Issues
- DUE MONDAY NIGHT:
  1. ~~Chapter Reviews: 8~~
  2. HW05
- In Class Participation:
  1. FINAL EXAM 1 hour
  2. Discuss homework and chapter reviews (Test)?
- Return Meters to Library!

Appendix B – Sample Power Point

Listing of Power Points for class:

1. SUSTN106 IPMVP 2012 CH01 Introduction to IPMVP.pptx
2. SUSTN106 IPMVP 2012 CH02 Definition and Purposes of MV IPMVP 2012.pptx
3. SUSTN106 IPMVP 2012 CH03 Principles of M&V.pptx
4. SUSTN106 IPMVP 2012 CH04 Framework and Options a.pptx
5. SUSTN106 IPMVP 2012 CH05 M&V Plan.pptx
6. SUSTN106 IPMVP 2012 CH06 M&V Reporting.pptx
7. SUSTN106 IPMVP 2012 CH07 Adherence with IPMVP.pptx
8. SUSTN106 IPMVP 2012 CH08 Common M&V Issues.pptx

Other Optional Power Points:

1. Gas Electric Meter Reading.pptx
2. Determining Utility Rate from billing.pptx
3. Lighting Measurements IES.pptx
4. Utility Bill Discussion.pptx

Sample Power Point: SUSTN106 IPMVP 2012 CH01 Introduction to IPMVP.pptx

Chapter 1: Introduction to IPMVP

International Performance Measurement and Verification Protocol

IPMP #1

Purpose And Scope Of IPMVP

Increase world wide investments in:

1. Energy Efficiency
2. Water Efficiency
3. Demand Management
4. Renewable Energy projects

IPMP #2

Preface

- IPMVP is a guidance document
- It is for energy or water efficiency projects

IPMP #3

IPMVP is not a standard!

- No formal compliance mechanism to adhere to IPMVP
- Formal compliance are things such as LEED or codes

IPMP #4

How Does IPMVP Increase Investments?

- By documenting common terms
- By documenting common methods to evaluate performance of ***Efficiency***

Can be used in project agreements, but IPMVP does not offer contractual language

IPMP #5

How Does IPMVP Increase Investments? (cont.)

- Describes the M&V plan which follows industry best practices
- These best practices produce verifiable results, can be tested in the future with same method
- Plans should be developed by qualified professionals (you could be one!)

IPMP #6

Sample Power Point: SUSTN106 IPMVP 2012 CH01 Introduction to IPMVP.pptx (continued)

How Does IPMVP Increase Investments? (cont.)

- By applying to a large variety of facility and process types.
- Existing and new buildings or industrial processes

International Performance Measurement & Verification Protocol #7

How Does IPMVP Increase Investments? (cont.)

- Targeting different levels of project cost and accuracy for determining savings
  - Whole Building – large projects affecting more than 10% of the building energy use (could be lower but ….).
  - Individual Energy Conservation Measures (ECMs) – Small portion of facility energy use

International Performance Measurement & Verification Protocol #8

There Are Three Volumes

- Vol 1 – covered in this class, The basics of M&V
  1. What is M&V
  2. Fundamental principles
  3. Frame works and Options
  4. M&V Plan
  5. M&V Report
  6. Adherence to IPMVP
  7. M&V Issues
  8. Definitions

International Performance Measurement & Verification Protocol #9

Two Other Volumes

(*not covered in this course*)

- Vol II
  - Indoor environmental-quality related to ECM design, implementation, and maintenance
- Vol III
  - More Detail on M&V methods for new buildings and renewable energy systems

International Performance Measurement & Verification Protocol #10

Benefits Of Using IPMVP

- Validation of savings paying for projects
  - Adherence to IPMVP good or best practices
  - Repeatable verification
  - Helps with payment to supplies / ESCOs
- Helps with negotiations of contracts, lowering costs of energy performance contracts
- International Credibility of energy savings reported – increases value

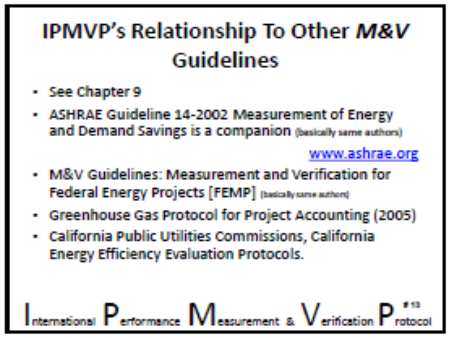
International Performance Measurement & Verification Protocol #11

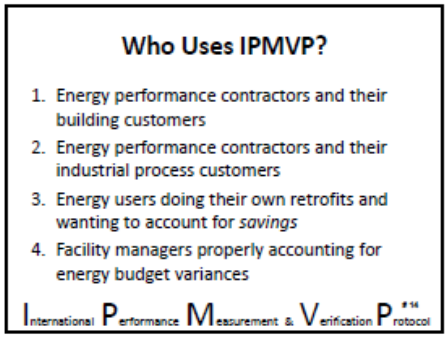
Benefits Of Using IPMVP (cont.)

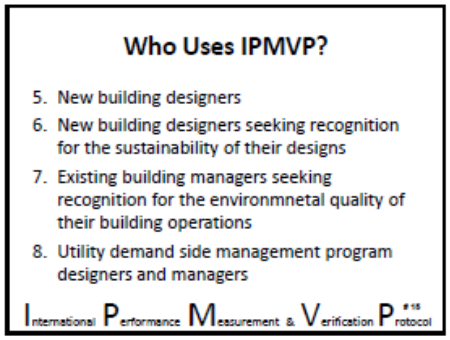
- Enhanced rating under programs (LEED, Energy Star, Utility programs or demand side management programs such as Focus On Energy)
- Helps national and industry organizations promote efficiency (standard followed for credibility)
- Governments agencies recognize it

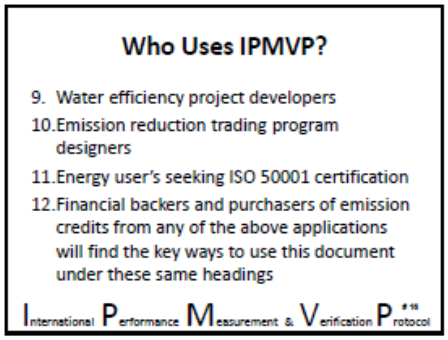
International Performance Measurement & Verification Protocol #12

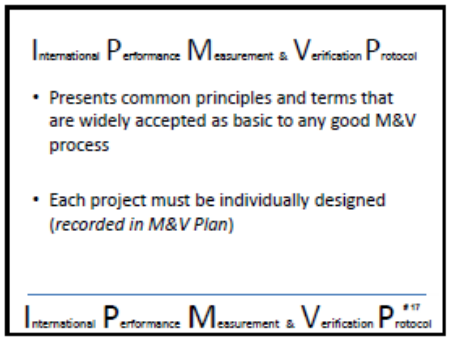
Sample Power Point: SUSTN106 IPMVP 2012 CH01 Introduction to IPMVP.pptx (continued)











Appendix C – Sample Homework

Listing of Homework for class:

1. HW01 Utility Meter Readings
   - Student must find gas, water and electric meters to read and document readings on at least two days. Write down the date and times. Go online and find the average daily temperatures from Weather Underground (see Web Sites Tab) and enter that data. NOTE: Student must have access to these meters for several weeks so you can complete HW02. A spreadsheet is provided to enter data.
2. HW02 Utility Meter Readings Log
   - This homework will be weighted heavier than other homework (at least equivalent to two homework). NOTE: The file has a meter reading hints tab that should state for the gas meter "9 therms or 900 cubic feet" not the 10 therms stated.
   - This is a long term assignment that requires at least 21 days of meter readings (at least one each day). It is OK to have gaps (more than one day between readings) but there must be at least 21 days with a reading.
   - Use the spreadsheet provided. Submit intermittently in blackboard to ask questions.
   - There is also an old sample spreadsheet that you can refer to for information.
3. HW03 Kill-A-Watt, using the meter
   - The purpose of this homework is to: 1) familiarize Student with the Kill-A-Watt meter; 2) See that appliances, as all equipment, do not operate at one load all the time; 3) See how the various electrical measurements vary with load. Remember the wattage equation: watts = volts x amps x PF.
   - As with all your work, Student must: 1) name the file in a way that the instructor knows it is you, 2) place your name on each tab; 3) Date / time stamp everything! Your grade will also be based on how Student use this spreadsheet (formatting - including significant decimal places, equations, ease of printing). This is not only about M&V, but also about presenting your information so clients (or lawyers for that matter) can understand it.
   - Student must use one tab for each of five different appliances around the home or elsewhere.
4. HW04 Kill-A-Watt Long Term Metering
   - This is the next step of using the Kill-A-Watt meter, learning how to meter kWh and extrapolate the data to a full year. Select two of the items metered in HW03 that are used regularly (examples, refrigerators, TVs, computers). These must be items plugged in and used during the measurement period and of larger loads. Smaller items could be used (get approval from instructor) but have to be measured for longer periods of time - several days for instance.
   - For two of the items metered in HW03, meter each for a minimum of 24 hours and enter the starting data, any interval data, and a final before you remove the Kill-A-Watt from the outlet.
   - Your electrical rate must be used. Commentary is expected.
   - The data you collect for these two items must have the information extrapolated to a year to determine annual usage (kWh) and cost ($).
5. HW05 T&RH Data Logger and Analysis

   Using the T&RH data logger do the following:
   - You must have a minimum of one week of readings plotted.
   - At least three days have to be outside.
   - There has to be 3 different sets of T&RH data (say outside air, thermostat or inside the home, inside car, inside refrigerator) that add up to a full week of readings.
   - All data must be supplied in a spreadsheet and the data files from the logger supplied.
   - For each of three sets of data, the following must be provided:

- A table for each set of data and each day containing:
- T&RH for each 24 hour period: Maximum, Minimum, and Average
- For the outside temperature, a comparison to weather underground has to be made.
- A comparison to of the average T&RH to the result of adding the (Max + Min) / 2.
- The last item is what is typically used as the average temperature for a given day by sites such as weather underground. Is that accurate?
- A description of what was measured and the resulting readings, accounting for variations (such as weather changes, furnace kicking in, riding in car, car not being used, etc.)

It is expected that all information will be presented in a readable format that can easily be followed and traced back to the detailed data collected.
All information will be electronically uploaded for grading.
A few things:

- Write in third person, no "I", "my", "me". Just state facts. "Temperature and Relative Humidity Readings in the Wilinski household Friday 2/21 through Monday 2/24" "Relative humidity increased at this point because the shower was used at 8 PM. The bathroom fan was not turned on."
- When writing notes on data, make sure you explain what you checked on as well as the result for changes in conditions. Not knowing what caused something but having checked off some of the obvious or possible reasons is important and better than merely stating you do not know why something happened.
- Also, note that when the temperature goes up and relative humidity will go down unless there is something adding moisture to the air.
- Due to the complexity of this homework, it will be weighted more than others.
- A preliminary or progress submittal is due March 10 as "HW05a Preliminary"

Example Homework, HW01 Utility Meter Readings

HW01 Utility Meter Readings

Attached Files:

- YOUR NAME HW01 Utility Meter Readings Log(1).xlsx (298.396 KB)
- YOUR NAME HW01 Utility Meter Readings Log(1).pdf (417.892 KB)

DUE Monday 02/03/2014 at 11:59 PM in Blackboard

You must find gas, water and electric meters to read and document readings on at least two days. Write down the date and times. Go online and find the average daily temperatures from Weather Underground (see Web Sites Tab) and enter that data.

NOTE: You must have access to these meters for several weeks so you can complete HW02. Submit in Blackboard the day before the next class and **bring a copy to second class** to discuss.

Meter Readings

TYPE YOUR NAME: FACILITY HERE

Electric mtr# _____ Average OA Temp for Day

	Date	Time	Day of Week	Reading Date	Reading Time	Day of Wk	reading	Average OA Temp for Day
METER READING #1						Tuesday		°F
METER READING #2						Tuesday		°F
						Difference		
METER READING #1						Tuesday		°F
METER READING #2						Tuesday		°F
						Difference		

Comment On Electric Readings: (how does it compare to the data at the right for instance) .

Gas mtr# _____ Average OA Temp for Day

	Date	Time	Day of Week	Reading Date	Reading Time	Day of Wk	reading	Average OA Temp for Day
METER READING #1						Tuesday		°F
METER READING #2						Tuesday		°F
						Difference		
METER READING #1						Tuesday		°F
METER READING #2						Tuesday		°F
						Difference		

Comment On Gas Readings: (how does it compare to the data at the right for instance) .

Water mtr# _____ Average OA Temp for Day

	Date	Time	Day of Week	Reading Date	Reading Time	Day of Wk	reading	Average OA Temp for Day
METER READING #1						Tuesday		°F
METER READING #2						Tuesday		°F
						Difference		
METER READING #1						Tuesday		°F
METER READING #2						Tuesday		°F
						Difference		

Comment On Water Readings: (convert into gallons and consider what you do in your house to see if it makes sense) .

Appendix D – Sample Quiz

Listing of Quizzes for class:

- Quizzes based on International Performance Measurement and Verification Protocol (IPMVP): Concepts and Options for Determining Energy and Water Savings – Volume 1
    1. CH01 IPMVP 2012
    2. CH02 IPMVP 2012
    3. CH03 IPMVP 2012
    4. CH04 IPMVP 2012 01
    5. CH04 IPMVP 2012 02
    6. CH05 IPMVP 2012
    7. CH06 IPMVP 2012

Below is an example Quiz for this course:

SUSTN106 M&V IPMVP Ch 1 2012

TRUE/FALSE

1. The purpose of the IPMVP (International Performance Measurement and Verification Protocol) is to increase investment in energy and water efficiency, demand management and renewable energy projects around the world.

   ANS: T PTS: 10

2. IPMVP is a standard much like ASHRAE develops that eventually will be integrated into codes.

   ANS: F
   No it is not. This is a guiding document that provides a framework for M&V activities.

   PTS: 10

3. IPMVP is required on all energy saving projects

   ANS: F
   It is not a standard or a law so it cannot be forced on every project.

   PTS: 10

4. ASHRAE (the American Society of Heating, Refrigeration and Air conditioning Engineers) also has an M&V guideline

   ANS: T
   True - it is ASHRAE Guideline 14-2002, Measurement of Energy and Demand Savings

   PTS: 10

5. Applying IPMVP is unique to each project

   ANS: T PTS: 10

6. An M&V Plan can actually be part of an energy-performance contract (but IPMVP does not provide contract language).

   ANS: T PTS: 10

7. ESCOs (Energy Service Company) can use the IPMVP to provide the basis for a contractual agreement between the ESCO and their customers. For instance, Johnson Controls could use the M&V Plan directly as part of the contract.

   ANS: T
   However, IPMVP is not contract language so the ESCO has to make sure it conforms to their needs.

   PTS: 10

8. One of the nice things about using IPMVP for building owners is it helps to justify investments and add credibility to requests for future investments.

   ANS: T PTS: 10

MULTIPLE CHOICE

1. The IPMVP stands for:

   a. International Performance Measurement and Verification Protocol
   b. Individual Project Measurement and Verification Protocol
   c. International Performance Measurement and Validation Protocol
   d. International Performance Measurement and Validation Process

   ANS: A PTS: 10

2. ESCO is the abbreviation for

   a. Energy Systems Company
   b. Energy Service Companies
   c. Electrical Systems Cooperative
   d. Energy Saving Construction Optimization

   ANS: B
   Examples of ESCOs are Johnson Controls, Honeywell, McKinstry

   PTS: 10

MULTIPLE RESPONSE

1. IPMVP has several Volumes. Select all that apply:
   a. Volume I defines M&V fundamental principles
   b. Volume II is for indoor environmental quality issues.
   c. Volume III is geared toward new buildings and renewable energy systems for new buildings
   d. Volume I is all that is specifically addressed in this course.

   ANS: A, B, C, D PTS: 10

2. IPMVP is intended to increase investment in: Select all that apply

   a. energy efficiency
   b. production efficiency
   c. educational efficiency
   d. water efficiency

   ANS: A, D PTS: 10

3. IPMVP applies to a wide variety of facilities including: Select all that apply

   a. management practices
   b. existing buildings
   c. industrial buildings
   d. new buildings

   ANS: B, C, D PTS: 10

4. IPMVP promotes efficiency through: Select all that apply

   a. standardizing terms and methods to evaluate performance
   b. providing methods with different levels cost and accuracy for determining savings
   c. specifying the contents of an M&V plan
   d. providing funding through local energy efficiency programs

   ANS: A, B, C
   However, it does not provide any funding, although if it did, going through a local energy efficiency program would be a good way to do it.

   PTS: 10

5. Who are some of the people who would use IPMVP? Select all that apply

   a. Energy Performance contractors
   b. Industrial process people
   c. Energy users doing their own retrofits
   d. Facility managers
   e. People seeking LEED certification for a building

   ANS: A, B, C, D, E
   It is not really limited by who it applies to, you just have to have a need for it.

   PTS: 10

BEST Center Curricula, Resources & Recordings

Academic Programs
Georgia Piedmont Technical College - Building Automation Systems
Milwaukee Area Technical College - Sustainable Facilities Operations
Laney College - Commercial HVAC Systems
City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos
National Institutes
Building Automation Systems Instructor Workshops
Webinars (e.g., BEST Talks)

Faculty Profile Videos
Reports & Case Studies
Marketing Resources

BEST
Building Efficiency for a Sustainable Tomorrow

NSF National Science Foundation