UMass Amherst Building Measurement, Verification, Coordination and Template Plan

Green Building Subcommittee
Chancellors Sustainability Committee
University of Massachusetts Amherst
413-577-1787

M&V COORDINATION BETWEEN UMA AND PROJECT TEAMS:

- UMA will be responsible for monthly data collection & transfer to the M&V Agent (MVA) during the pre-defined M&V collection period. Stewardship of this data is the responsibility of the UMA Green Building Committee. http://www.umass.edu/sustainability/get-involved/green-building-subcommittee

- The MVA is a separate entity hired by the project team, not necessarily affixed as a sub to the design or construction team, but nevertheless funded by the project. The MVA is responsible for:

    - Developing the official M&V Plan for the project
    - Managing and/or performing **a pre-M&V period** calibration of the proposed case energy model, incorporating air/water balance results and any equipment substitutions, etc., due to construction, that change the performance ratings of the systems vs. as designed scenarios.
    - Analyzing monthly data received from UMA, including full access to the Campus BAS (JCI Metasys) as needed
    - Documenting any system operating adjustments made during the M&V period (typically as a result of suggestions by the CxA during their post-occupancy period analysis or by continuous O&M adjustments by UMA Physical Plant staff)
    - Generating an M&V Report at the end of collection period, with recommendations for further adjustments to optimize the building systems

- Adjustments to the energy model will also most likely be handled as a separate entity hired by the project team. This could be the original energy modeler, the MVA, or a 3rd party entity. Regardless, this would also be funded by the project. Typically, this would not be the mechanical designer or the mechanical contractor due to their biases.

    - Ideally, the energy modeler that did the original model would make the pre- and post-M&V adjustments.
    - However in case this is not possible, UMA would request that the energy modeler that did the original model share their working files with UMA or hired 3rd party, so that pre- and post-adjustments to the model could be made.
    - **At a bare minimum, UMA expects that the energy modeling parameters/Basis of Design be submitted** for pre- and post-M&V adjustments to the model, so that UMA or the hired 3rd party can replicate the model via separate resources.

- It should be noted that though the roles of the MVA and the Cx Agent (CxA) are similar (and therefore could be combined), they are not necessarily the same:

    - In addition to standard end-of-construction Cx, the CxA may be hired for post-occupancy Cx services in the form of continuous commissioning (CCx), a 6-mo/10-mo/12-month evaluation (or any combination thereof) …up to a 2 year typical commitment. This post-occupancy Cx service is not required, but is optional as project funds, LEED points, and overall value are assessed.

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- The MVA typically is identified prior to CD phase of the project, reviews the bid docs for necessary hardware needed to successfully complete M&V, and is a more-or-less passive observer of building consumption during the M&V period. It is not a role of the MVA to suggest and make recommended adjustments to the building systems during the M&V collection period.

- Since the MVA and firm that does the energy model adjustments are committed to the entire M&V period (usually 1.5 to 2 years), this arrangement (i.e. as separate entities, not affixed as a sub to the design or construction teams) seems to be the least conflicting way to keep the design/construction process take its natural course, and not have open-ended project accounts for many months post-occupancy.

Any questions or comments should be directed to Ted Mendoza, GBC Chair, at tmendoza@facil.umass.edu or (413) 545-6564.

University of Massachusetts Amherst Measurement & Verification Guidelines & Template Plan

11/19/2013

Green Building Subcommittee
Chancellors Sustainability Committee
University of Massachusetts Amherst
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UMASS Amherst Measurement & Verification (M&V) Guidelines

Preface

Measurement & Verification of building performance is a critical component of confirming that buildings constructed or renovated on the UMASS Amherst campus are performing as promised/designed and that we are actually meeting our reduced energy consumption and Green House Gas (GHG) goals. Accurate confirmation of savings produced from energy conservation measures is crucial to the success of our building and renovation projects. The UMASS Amherst Green Building Committee recommends that all UMASS Amherst New Construction projects and all Major Renovation (as defined below) projects achieve LEED Silver certification and strive to achieve Energy Performance that is 20% better than the current applicable Energy Code.[1]

Benefits of Measurement & Verification

- Compliance with LEED and/or Energy Star requirements
- Verification that we are achieving our Energy Use Reduction and Green House Gas Emission Reduction Goals.
- The energy data and analysis obtained can be used in building management decisions.
- M&V provides feedback for future design of "Green Buildings" and can fuel Research and Educational Initiatives
- The process and metering implemented under M&V will provide feedback of facility performance over the life of the building. Poor energy performance of equipment is often an indication of the need for maintenance or replacement.
- Assurance of building energy efficiency by providing accurate reporting of savings resulting from the energy strategies/conservation measures implemented.
- Verification of energy savings and performance of mechanical, electrical, and other system change outs or renovations (i.e. "if we replace all the windows in a building, how much better is the building performing?")
- Provides documentation that is often needed for the University to obtain utility company rebates and incentives.

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[1] The Massachusetts LEED Plus standard was adapted in 2007 and required energy performance to be at least 20% better than the energy code that was in effect in 2007 (IECC 2006/ASHRAE 90.1-2004). Since then the energy code has been updated twice and the current code (IECC 2012/ASHRAE 90.1-2010) is already inherently more stringent than the codes that were in place in 2007. Therefore, the GBC recognizes that exceeding the current code by 20% may be difficult for some projects (particularly Major Renovation projects) and as such the requirement shall be at a minimum to **meet** the current energy code and "to strive" to exceed the current energy codes by 20%. It should be noted that the LEED rating systems **still require performance in excess of the current code** to achieve any points under EAc1 and performance must be below the applicable ASHRAE standard to meet EAp2.

Implementation of M&V will also help us Continuously Commission or Retro-Commission our buildings. Continuous Commissioning has been shown to provide real benefits and cost savings over the life of a building.[2]

LEED certified buildings, on average, perform better (energy-wise and environmentally) and are healthier for their occupants than contemporary buildings that are not LEED certified.[3] Measurement & Verification allows UMASS Amherst to confirm this and to identify and correct problems that can arise in these buildings.

Lesson Learned

All three of UMASS Amherst's LEED Gold certified buildings have had some elements that needed correction after occupancy began.

UMASS Police Station
Actual electrical energy use in the first year of occupancy was 70% more than modeled/projected. Investigation and analysis by the UMASS Physical Plant revealed several HVAC/Control issues. The contractor made corrections based on UMASS Physical Plant recommendations and energy use is now only 30% more than projected. If full M&V had been performed, the cause for this remaining discrepancy might have been discovered, such as the possibility that the original models may not have accurately reflected actual occupancy schedules.

Minuteman Marching Band Building
While monitoring BAS system, UMASS PP noticed temperature discrepancies in the air flow stream. An analysis revealed that a revised HVAC layout had overlooked some needed outside air dampers and controls. The controls contractor installed the needed equipment and the performance of the building has been better than predicted.

CNS Research Greenhouse
Actual water use during 1st year was much higher than anticipated. Due to lack of sub-metering, it is unknown if this overage is due to the operation of the facility (i.e. greenhouse irrigation requirements) or to some other cause. Electrical use is also double what was projected but analysis is difficult due to lack of reliable meter data.

Measurement &Verification Costs and Potential Savings

Costs for the additional meters (and some level of load separation) to facilitate Measurement and Verification can add $2 to $4 per square foot to the cost of a project. In addition, the cost of an

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[2] Spade, Katrina; Burbank, Jason; and McCusker, Katherine, "UMass Amherst Continuous Commissioning Proposal: Potential Costs, Cost Savings and Required Resources" (2012). UMass Amherst Campus Sustainability Initiative. Paper 9. http://scholarworks.umass.edu/csi/9

[3] National Academy of Sciences (U.S.),, National Academy of Engineering,, Institute of Medicine (U.S.),, & National Research Council (U.S.),. (2013). *Energy-efficiency standards and green building certification systems used by the Department of Defense for military construction and major renovations*.

M&V consultant can range from $50,000 to $120,000 (Morris and Matthiessen 2008). These costs represent an average of 7% of the potential cost savings over the life of the project. (Walker, et al 1999). As noted above, M&V also contributes to the ability to perform Continuous Commissioning and Retro-Commissioning and to the savings that can be realized from these processes over the life of a building.

Application to Major Renovation Projects

The USGBC LEED ratings systems define "Major Renovations" as; "Includes extensive *alteration* work in addition to work on the *exterior shell* of the building and/or *primary structural components* and/or the core and peripheral MEP and service systems and/or site work. Typically, the extent and nature of the work is such that the *primary function space* cannot be used for its intended purpose while the work is in progress and where a new certificate of occupancy is required before the work area can be reoccupied."[4]

The Commonwealth of MA Department of Administration & Finance, in A&F Bulletin # 12 (Aug 11, 2006) defined Major Renovations as follows; "Major renovation projects are defined as those projects that include a complete overhaul of a significant portion of the original structure and where the cost of the renovation is greater than 50% of the assessed value of the building." The main goal of the standard is further defined:

> "The standard below is designed to ensure that state buildings constructed and renovated in such a manner will result in buildings that are at least 20% more efficient than the current energy code, provide healthier indoor spaces for workers, residents, and visitors, use natural resources wisely, and reduce the overall long-term operating costs associated with heating, cooling, powering and generally managing the property. A higher up-front cost for a sustainably designed and constructed building shall not preclude its construction unless, after accounting for all incentives and rebates, such costs cannot be justified with a reasonable payback period of 10 years or less. Agencies shall work to utilize an integrated design and construction process that ensures that these goals are considered during each of the design and construction phases."

For the purpose of this guide Major Renovations will be defined in accordance with the A&F Bulletin.

Since each renovation project is unique and it may not be apparent if the proposed LEED and energy performance requirements apply, project teams are requested to consult with the Green Building Subcommittee in making a determination.

Responsibilities for the M&V Process

The Green Building Committee recommends that the implementation of M&V be a collaborative process between the various divisions of Facilities & Campus Services and an M&V Agent. The

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[4] Rating Selection Guidance last updated September 1, 2011 © 2011 U.S. Green Building Council, Inc.

M&V Agent will be a consultant retained specifically for the project and may be the same entity as the Independent Commissioning Agent. The M&V agent should not be the Designer or the Contractor/Construction Manager.

Campus Planning (CP) and Physical Plant (PP), in conjunction with the Green Building Researchers, will assist the project team with the development of the M&V plan and with guidance during the design process such that M&V can be efficiently implemented.

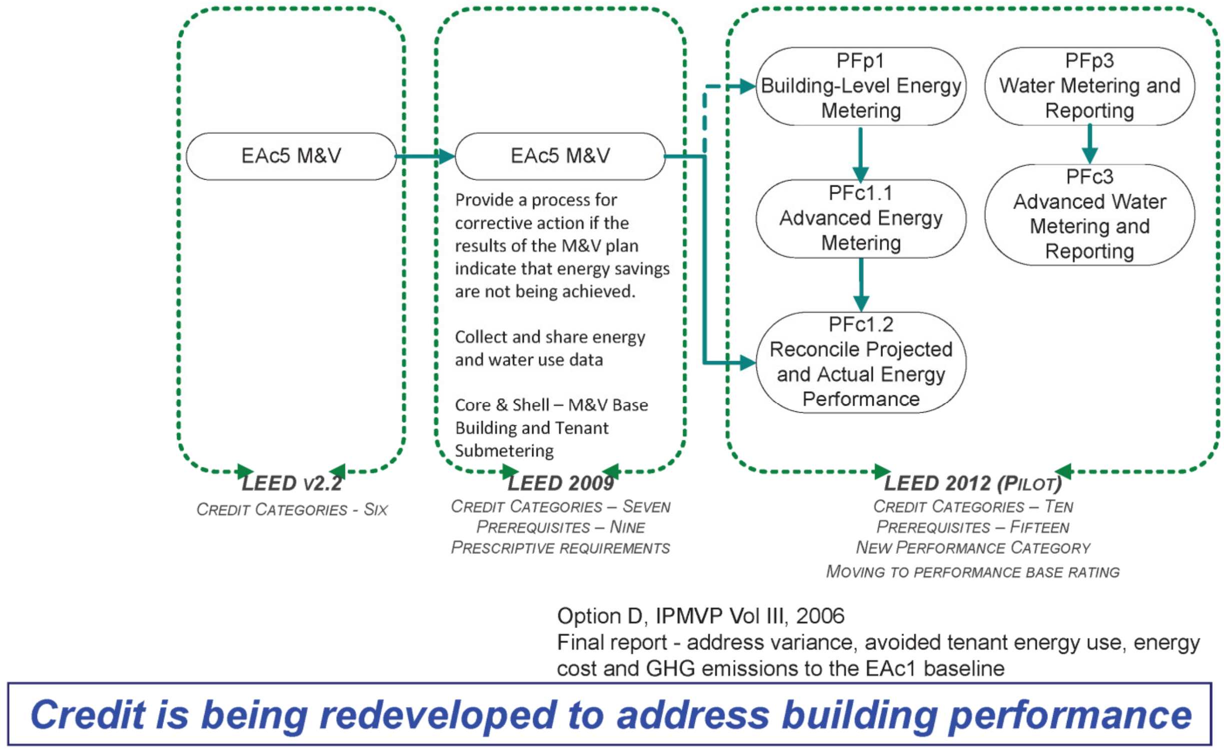
Design and Construction Management (DCM) will oversee the M&V process during construction and commissioning. This would include the installation, testing, and calibration of the required building utility meters and sub-meters as required by the M&V plan and the correction of all Design and Construction deficiencies identified during the Commissioning process.

Under the direction of the DCM Project Manager and with the assistance of the Green Building Researchers and UMA Physical Plant, the M&V Agent will conduct the one year monitoring period following occupancy. The M&V agent will be responsible for collecting and analyzing all data needed to complete the M&V process including the development of calibrated baseline and as-built energy models.

The M&V agent will prepare an Initial M&V report at the end of the one year period that presents all of the M& V findings, including the actual performance of the building as compared to the baseline and design models. If performance is less than the design projections, the M&V agent will prepare a corrective action plan. The University may choose to perform the corrective actions through the Physical Plant Division or may hire the contractors involved in the project to complete this work. If the commissioning process has been completed successfully, it is not anticipated that the corrective actions necessary are the result of any unresolved contractor errors or omissions.

The M&V agent will be responsible for preparing a final report that will document the M&V process, the findings during the first year of occupancy, the verified performance of the project, the corrective action plan, and the results of the corrective action plan. Included in this report will be all of the data that has been collected over the life of the M&V process. This report will be presented to the UMASS Amherst Physical Plant Division as a resource for the continued Commissioning, Operation, and Maintenance of the building. Campus Planning and Design and Construction Management may also use this report to inform the design and procedures to be used on future projects.

Finally, it should be noted that LEED Version 4 will require documentation of building performance. By implementing M&V at this time, even for projects being built under LEED Version 3, UMASS Amherst will position itself in a Leadership role in implementing the new standard.



Leadership in Energy and Environmental Design(LEED®) U.S. Green Building Council (USGBC)

University of Massachusetts' Sustainability Efforts

As signatories of the University & College President's Climate Commitment (ACUPCC), the University of Massachusetts Amherst has taken on the challenge of constructing a new class of sustainable buildings that demonstrate its commitment to save and protect the environment and to provide its students, faculty, and staff with comfortable, healthy, and sustainable spaces for use in the pursuit of the overall goals of the university.

Milestones

- The University of Massachusetts System (including UMASS Amherst) signed into ACUPCC in 2007
- UMASS Amherst's award winning Central Heating Plant began operation in 2009, significantly reducing campus emissions and increasing the efficiency of campus energy generation.
- Between 2007 and 2012, the campus-wide energy & water conservation measures helped offset the requirement for energy and water from new buildings and an expanded enrollment.
- UMASS Amherst is one of 47 STARS Gold Universities/Colleges
- UMASS Amherst 1st LEED building was certified Gold in 2012, Two other projects have been certified LEED Gold.

- UMASS Amherst has 8 additional completed buildings awaiting LEED certification.
- UMASS Amherst has another 9 buildings in the planning or construction phase that will be seeking LEED certification
- UMASS Amherst named to Top 20 "Green Honor Roll" in the nation in sustainability in August 2013 by Princeton Review

UMASS Amherst Green Building Subcommittee Sustainability Goals

In Massachusetts, the Governor's Executive Order 484 established goals for state agencies regarding sustainability, energy performance, and LEED certification. The Green Building Subcommittee of the Chancellor's Sustainability Committee recommends that UMASS Amherst adopt these goals, particularly those related to building performance. The suggested percentage improvements shall be determined against the baseline building performance rating per ASHRAE 90.1-2007/2012 and/or IECC 2009/2012 as applicable to the timeline of the particular project. The goals are as follows;

- Reduce greenhouse gas emissions that result from state government operations by 25% by Fiscal Year 2012, 40% by 2020 and 80% by 2050. In calculating emissions, agencies shall use Fiscal Year 2002 as the baseline, and emissions reductions shall be measured on an absolute basis and not adjusted for facility expansion, load growth, or weather.
- <u>Reduce overall energy consumption at state owned and leased (at which the state pays directly for energy) buildings by 20% by Fiscal Year 2012 and 35% by 2020. Such reductions shall be based on a **Fiscal Year 2004 baseline** and measured on a BTU per square foot basis.</u>
- Procure 15% of agency annual electricity consumption from renewable sources by 2012 and 30% by 2020. This mandate may be achieved through procurement of renewable energy supply, purchase of renewable energy certificates (RECs) in accordance with EOEEA guidance and/or through the production of on-site renewable power. Only renewable sources that qualify for the Massachusetts Renewable Portfolio Standard (RPS) shall be eligible. Alternative compliance payments under 225 CMR 14.08 shall not be required under this Order.
- Utilize bio heat products with a minimum blend of 3% bio based materials for all heating applications that use #2 fuel starting with the winter of 2007-2008, and 10% bio heat blend by 2012.
- All new construction and major renovation projects must meet the Mass. LEED Plus green building standard established by the Commonwealth of Massachusetts Sustainable Design Roundtable.
- Reduce potable water use, as compared to 2006, by 10% by 2012 and 15% by 2020.

<u>Introduction to Measurement and Verification</u>

The purpose of this document is to provide guidance and a template plan[5] for the University of Massachusetts Amherst's implementation of the Measurement and Verification (M&V) process

[5] The M&V Plan shall comply with IPMVP, Volume III guidelines. Systems commonly included in an M&V Plan include (where applicable): Lighting & lighting controls, constant and variable motors, HVAC

as outlined by the International Performance Measurement & Verification Protocol/Efficiency Valuation Organization (IPMVP/EVO) and as required by the US Green Building Council for the Leadership in Energy and Environmental Design (LEED) Energy & Atmosphere Credit 5. This guide and plan describe the requirements for the measurement and verification of the Energy Conservation Measures (ECM's) integrated into the project during the design phase and/or for an integrated design, construction, and operation process covering whole building performance. The initial implementation of this guide & plan will be for New Construction (NC) and Major Renovation (MR) projects seeking LEED certification under LEED for New Construction 2009. For LEED projects, M&V must be conducted for one year following the completion of construction and the initiation of building occupancy and a corrective action plan provided if deficiencies are identified.

Following the successful implementation for LEED projects, it is anticipated that this guide and the template plan will be used for M&V on non-LEED projects and/or other renovation projects where verification of the performance and/or energy savings from ECM's is desired. This can aid in obtaining utility rebates or incentives and help UMASS Amherst assure itself that all of its facilities projects are resulting in reduced energy consumption/costs and lowered emissions.

The intent of this plan is to provide initial guidance and an M&V template plan that can be used by project managers and project designers such that the University can accurately determine the actual energy savings by using the principles as described by the IPMVP. The IPMVP provides the framework and broad approach to the techniques used for the determination of savings associated with energy conservation strategies.

Furthermore, the implementation of M&V is intended to help the University verify the cost & emissions savings associated with energy efficiency measures incorporated into the design construction, and operation of facilities, and to provide it with a recalibrated energy model that will serve as a tool for building operators in identifying and remedying problems and causes of underperformance and/or over-consumption over the life of the building. **For this reason, energy models should be developed utilizing software that is available to the University's staff.** If there is compelling reason to utilize software that must be purchased for the project, the project should include the cost of providing the software, training, and at least a 5 year license to the University.

LEED Certified Buildings & Performance

The argument as to whether LEED certified or "Green" buildings actually perform better than a conventionally constructed building has been raised by critics of the LEED program. A comprehensive evaluation[6] done for the U.S. Government/Department of Defense, which

loads/systems/equipment/controls, hydronic heating, domestic water heating, building-related process energy systems/equipment, general water use, process water use, process refrigeration.

[6] National Academy of Sciences (U.S.),, National Academy of Engineering,, Institute of Medicine (U.S.),, & National Research Council (U.S.),. (2013). *Energy-efficiency standards and green building certification systems used by the Department of Defense for military construction and major renovations*.

operates nearly one half million facilities, found that, on average, LEED certified buildings did perform better than conventionally constructed buildings with regards to the energy and water use. This study (co-authored by UMASS Amherst ECO/BCT Professor Paul Fisette) did point out that there were exceptions in that some LEED certified buildings performed poorer than the average for non-LEED buildings.

Thus it is imperative that UMASS Amherst assure itself, through the process of Measurement & Verification that its buildings are performing significantly better than average. In addition to recommending the continued reliance on LEED as a path to better performance, the study also recommends that policies and resources be put in place to measure the actual performance of high-performance, green, and conventional buildings.

One other finding of interest to UMASS Amherst is that the initial costs related to LEED certification are "relatively small" compared to the savings that can be realized over the life of the building.

Therefore, it shall be the policy of UMASS Amherst that LEED Credit EA 5 "Measurement & Verification", in its full value of 3 points, **shall be required** for all New Construction (NC) or Major Renovations (MR) projects that are seeking LEED certification under LEED for New Construction 2009.

The Basis for M&V

Accurate confirmation of savings produced from energy conservation measures (ECM) is crucial to the success of energy savings projects. The Department of Energy along with other nationally recognized technical advisors have developed an industry standard protocol that defines basic concepts and ideas for measurement and verification of energy conservation strategies in facilities. The resulting document is the International Performance measurement and Verification Protocol (IPMVP). The concept used for this plan is based on the IPMVP document. The IPMVP consist of four different approaches (A, B, C & D) for the measurement and verification of savings.

A brief description of these options is as follows:

Option A - Measurement of Key Parameters (Cannot be used for LEED)

Option A requires a pre measurement and a post measurement of each of the energy or water conservation measures taken. The measurements (typically along with hours of operation) are used for calculation of estimated savings. Some periodic inspections are generally required for verification of equipment operation, metering accuracy, operating hours, etc.

This option predicts savings using short-term or continuous measurements of the key operating parameter(s) along with estimated values. Key performance parameters are defined as the factors that affect the energy use of the ECM's system(s) and/or the project's success. Estimated parameters can be based on manufacturer's specifications, historical data, or engineering judgment; however, backup documentation and/or justification of the estimated parameter(s) is required.

Option B - Metered Savings of Equipment or Systems (This is LEED Option 2/UMASS Option 2)

Option B involves the continuous measurement of the post installation ECM or a sampling of equipment end-use energy measurement. Metering of the individual ECM or WCM is the main concept for this approach. **Option B is appropriate for the change out of specific systems so long as adequate pre and post energy use data is available.**

This option involves short-term or continuous metering of the baseline and reporting periods to determine energy consumption. Measurements are usually taken at the device or system level. Savings are determined for each efficiency measure. (Because incentive pricing is differentiated by measure category; lighting, HVAC, other equipment, etc., it is important to know how much energy was saved by each category of measure.)

Develop an M&V plan with the M&V period covering at least 1 year of occupancy. Plan shall incorporate the installation of building utility meters for each identified major service (electric, chilled water, domestic water, steam, gas, etc.) and the ability to continuously measure, record, and download data in 15 min intervals, minimum.

Verify that the systems affected by proposed ECMs do not interact with any other ECM, and then install sub metering devices, similar to building meters described for Option D (below). Calculate an estimated baseline usage as:

NC – within 10% of Adjusted National Average Source EUI (kBTU/SF)[7] for defined space type, plus within the generally accepted system energy usage % range of total building energy usage for defined building type. This data comes from the U.S. Energy Information Administration, an agency of the U.S. Government.

MR – within 10% of actual utility metered data averaged over the past 3 years (as possible), plus within the calculated system energy usage % range of total building energy usage for defined building type.

After one year of occupancy, compare estimated baseline energy performance with measured operating conditions. Within 6 month after the completion of the M&V one year period, UMASS shall develop a Corrective Action Plan, if M&V shows that the projected energy savings are not being achieved.

[7] This data can be found at http://www.eia.gov/consumption/commercial/about.cfm

Option C - Whole Facility Analysis Using Regression Models (Cannot be used for LEED)

Option C allows the use of a single building meter[8] to determine savings from a single or multiple ECM's. Continuous usage measurement or short-term measurements are taken during the post-retrofit period.

This option involves (1) comparing monthly billing data recorded by a utility meter or sub-meters for the whole facility or sub-facility level, before and after a project installation, and (2) analyzing the data using regression analysis to account for any variables, such as weather or occupancy levels. Energy savings can be determined once the variables are recognized and adjusted to match pre-installation conditions.

Option D - Computer Simulation (This is LEED Option 1/UMASS Option 1)

This will be the most commonly implemented method for New Construction (NC) and Major Renovations (MR). It may also be used for smaller renovation and retrofit projects if adequate pre-construction baseline data is not available.

Option D is the use of a calibrated computer simulation of post installation energy consumption to calculate savings resulting from the implementation of ECM's. This is the only option that can be used for New Construction projects. It must also be used for Major Renovation projects that involve multiple building systems.

This option involves using software to create a simulated model of a building based on design documents and site surveys. The model is calibrated by comparing it with end-use monitoring data or billing data. Models of the project are constructed for (1) the existing base case, (2) a base case complying with minimum standards, and (3) a case with the energy measures installed.

Typical simulation software that can be used for this option includes;

DOE-2.2/eQuest	(available for free from DOE website http://doe2.com/equest/index.html)
TRACE™ 700	(This is Trane's proprietary software and must be purchased, http://www.trane.com/Commercial/DNA/View.aspx?i=1136)
TRNSYS 17	(developed by the University of Wisconsin, must be purchased, http://sel.me.wisc.edu/trnsys/
IESVE for Architects/Engineers	This is commercially available software, http://www.iesve.com/

The M&V period must cover at least one year of occupancy after building construction and commissioning is complete.

[8] Multiple meters can be used if they are available

The plan shall require the installation of UMASS Amherst approved building utility meters for each identified major service (electric, chilled water, domestic water, steam, gas, etc.) and shall recommend the installation of sub-meters for identified sub load categories (HVAC, lighting, data centers, plug loads, process equipment, etc.). The installation of sub-meters also requires careful consideration regarding the separation of loads, spaces, and uses to the extent that it is feasible so that the sub-metered data can efficiently assist with the M&V process. For all meters, the ability to continuously measure, record, and download data in 15 min intervals minimum and to interface with the campus BAS system (Metasys™) shall be required. Building meters shall not serve more than one unique building. In instances where a project building and an existing building share utilities, separate metering should be included in the project scope so that energy & water use by both buildings can be measured.

UMASS Amherst Campus Design Guidelines

UMASS Amherst has established Campus Design Guidelines that should be reviewed by all Designers and Project Managers during the initial stages of the design of any project.

These guidelines were developed to present the University's preferences and criteria for the design and construction of campus facilities and landscape. The goal of the design guidelines is to improve the overall aesthetic character, visual unity, and sustainability of the Amherst campus as a whole. They represent the University's commitment for future buildings to create a more cohesive, attractive, productive and sustainable campus environment.

The following guideline documents are available in PDF format at the web site listed below.

Green Building Guidelines

Construction Design Guidelines

Utility Department Standards

UMass Amherst Campus Signage Guidelines

UMass Amherst Campus Landscape Design Standards

UMass Amherst Climate Action Plan

Audio-Visual Program Guidelines

UMass Amherst Room Numbering Guidelines

All of these guidelines are available at the following website:

http://www.umass.edu/fp/projectmanagement/designguidelines/

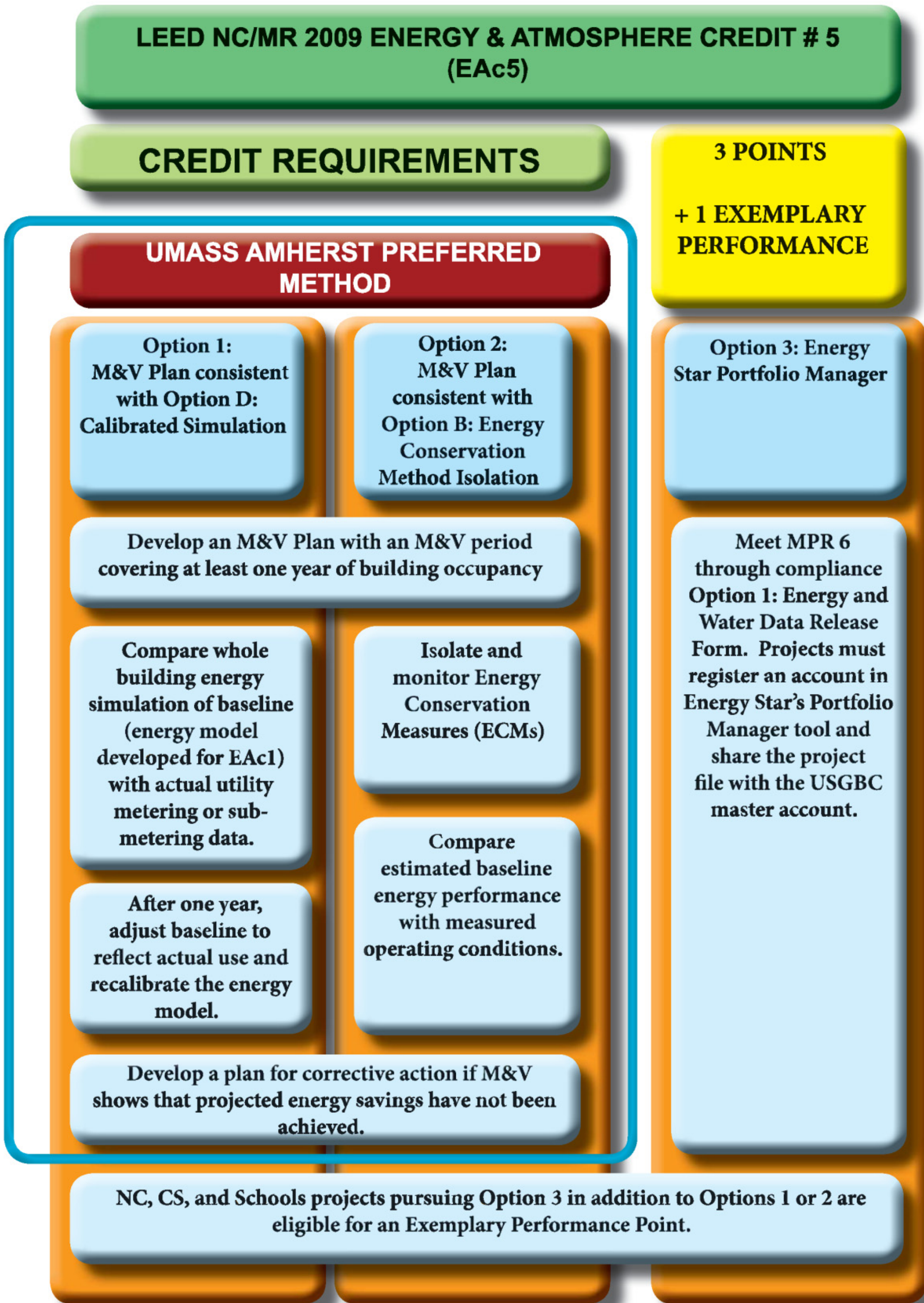
The requirements for building meters required by UMASS Amherst are also included in Appendix "C" Discussions about the required building meters and the necessary sub-meters and sub-metering strategy need to take place early in the design stage of the project and should be included any Requests for Proposals (RFP's) or Owner's Project Requirements (OPR's) issued by or on behalf of UMASS Amherst.

Data collection for the M&V process will be performed by an M&V Agent (Similar to and possibly the same as an Independent Commissioning Agent). Selected Plumbing, HVAC, Electrical, occupancy, and other control points will be monitored through the building automation system (BAS). If any points cannot be monitored using the BAS or if adequate data cannot be obtained through the BAS, independent data logging equipment will be used to capture the necessary data. This data will be downloaded and/or archived periodically, checked for possible gaps or errors, and periodic check-ups, maintenance, and analysis of the BAS or data collection process will be performed.

LEED

To qualify for the LEED 2009 Energy & Atmosphere Credit 5, Options B or D of the IMPVP must be followed to create the M&V plan. Option D will be the most commonly implemented M&V process since it is applicable to new construction projects. Full implementation of Measurement & Verification results in 3 LEED points under LEED NC 2009. Under LEED 2012 (Version 4), M&V will be incorporated into the Commissioning process and will become a requirement rather than an option[9] UMASS Amherst desires to proactively adapt full implementation of M&V as a mandatory requirement at this time.

[9] Reference to LEED 2012 (V4)



Graphic based on information from www.leeduser.com, retrieved 10/05/2013.

Figure 1 – LEED NC 2009 Energy & Atmosphere Credit 5 Process Diagram

Percentage Improvement above Baseline

This is how much better we want to be than the minimum requirements.

	What we would like to see		How did we do?
Energy Code & Standard (as of July 1 in the year referenced)	**Year**	**% Above Required Min.**	**% Improvement Achieved**
IECC 2009/ASHRAE 90.1-2007	2009	20%	
IECC 2009/ASHRAE 90.1-2007	2010	20%	
IECC 2009/ASHRAE 90.1-2007	2011	20%	
IECC 2012/ASHRAE 90.1-2010	2012	20%	
IECC 2012/ASHRAE 90.1-2010	2013	20%	
IECC 2012/ASHRAE 90.1-2010	2014	20%	
TBD	2015	20%	

For buildings with less than 20,000 SF, the ASHRAE Advanced Energy Design Guides (AEDG) can be used.

This guide to M&V is meant to act as a supplement to the UMASS Amherst Campus Green Building Guidelines and all of the Campus Design Standards. (See Appendix C).

Measurement & Verification Plan

(This is a template that should be modified and finalized by the project team)

Project Number and Name

University of Massachusetts Amherst
UMA##-##, Project Name
UMA Building Number: XXX
Project Address
Amherst, Massachusetts
Date

Insert Project
Rendering/Photo Here

UMASS Amherst Measurement & Verification Plan [Template]

Introduction to Measurement & Verification (M&V)

[The language from the UMASS Amherst M&V Guide may be inserted here as an introduction to M&V at the UMASS Amherst campus.]

Project Introduction

The [enter project name] at [enter project location] has been designed and constructed according to LEED-[enter LEED rating system to be used] criteria. [Describe the project in detail]

For addition information about the project design, please reference the following:

- Owner's Project Requirements (OPR) to be attached as Appendix A to this plan
- Mechanical Systems Narrative and Basis of Design (BOD) to be attached as Appendix B to this plan

Executive Summary

The measurement and verification plan for [enter project name] at the University of Massachusetts in Amherst, MA is to follow International Performance Measurement & Verification Protocol (IPMVP/EVO) consistent with [enter option to be used, Option D will be the most common choice]

The building use and occupancy is assumed to be the same for the base year and post-retrofit periods. The building occupancy assumptions are further described in the following sections and in Appendix D

Since baseline energy data is not available for the project, Option D as described in IPMVP/EVO shall be used. The base year energy consumption and demand will be calculated utilizing [enter energy modeling software program name and version], an energy simulation program created by [enter the source/creator of the energy modeling software program].

The simulation program will be utilized to determine that the proposed building will result in [energy, water, emission, etc…] savings. The proposed energy and water conservative measures integrated into the project will be measured utilizing the UMASS Amherst campus Building Automation System (BAS)[10] integrated meters and sub-meters (or other data collection methods) for each building system. Verification that energy and water conservative measures (as well as the meters and sub-meters) have been installed correctly will be performed by the Commissioning (Cx) Agent for the project.

[10] The UMASS Amherst Building Automation System is Johnson Controls, Inc. Metasys™ System

Project Background

[Name of Lead Designer] was selected by the University of Massachusetts Amherst (UMA) and the [Massachusetts Division of Capital Asset Management (DCAM) or UMASS Building Authority (UMBA)] as the [Lead Designer Discipline] for the [Name of Project] at the UMASS Amherst campus.

UMASS Amherst requires that this new facility be responsive to energy and environmental design considerations in order to reduce energy & water use, emissions, and operating costs and to provide a visible expression of sustainable development and design. UMA has established a sustainable design goal of Massachusetts Silver Plus under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system and Massachusetts Executive Order 484.

LEED

The LEED Green Building Rating System is a voluntary, consensus-based, market-driven building rating system based on existing proven technology. It evaluates environmental performance from a whole building perspective over a building's life-cycle, providing a definitive standard for what constitutes a "green building." LEED Energy and Atmosphere Credit 5 (EAc5), Measurement and Verification, provides for the ongoing accountability and optimization of building energy consumption performance over time. This Measurement and Verification (M&V) Plan provides a framework for accomplishing the accountability and optimization effort called for by the LEED credit.

Massachusetts LEED Plus Standard

The Mass. LEED Plus standard shall apply to all projects overseen by DCAM and any other executive agency, as well as those that are built for use by state agencies on state land. In addition, the Executive Office of Energy and Environmental Affairs (EOEEA) shall coordinate efforts to incorporate the Massachusetts LEED Plus standard into all non-executive branch agencies involved in construction. EOEEA and DCAM shall report each year on progress made with regard to integration of this standard into state building projects.

The UMASS Amherst campus has voluntarily adopted the Massachusetts LEED Plus standard as the minimum LEED standard for its New Construction and Major Renovation[11] project greater than 20,000 GSF.

The Massachusetts LEED Plus standard was adapted in 2007 and required energy performance to be at least 20% better than the energy code that was in effect in 2007 (IECC 2006/ASHRAE 90.1-2004). Since then the energy code has been updated twice and the current code (IECC 2012/ASHRAE 90.1-2010) is already inherently more stringent than the codes that were in place in 2007. Therefore, the GBC recognizes that exceeding the current code by 20% may be difficult for some projects (particularly Major Renovation projects) and as such the requirement shall be

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[11] As defined in the UMASS Amherst M&V Guide

at a minimum to **meet** the current energy code and "to strive" to exceed the current energy codes by 20%. It should be noted that the LEED rating systems would **still require performance in excess of the current code** to achieve any points under EAc1.

Third party building commissioning (LEED-NC 2009, Energy & Atmosphere, Prerequisite 1, Credit 3).

1. At least one of the four following Smart Growth criteria (unless the criteria conflict with another critical public policy objective):

    a. Construct or renovate on a previously developed site (LEED-NC 2009, Sustainable Sites, Credit 1). In a community with a minimum density of 60,000 square feet per acre or - Within one-half mile of ten basic services and a residential zone or neighborhood with an average density of ten units per acre; and with pedestrian access between buildings and services.

    b. Construct or renovate on a brownfields site (LEED-NC 2009, Sustainable Sites, Credit 3).

    c. Construct or renovate on a site with public transportation (train or bus) within one half mile of the project's main entrance (LEED-NC 2009, Sustainable Sites, Credit 4.1).

    d. Maintain 75 percent of existing building structure and envelope (LEED-NC 2009, Materials and Resources, Credit 1.1).

2. At least two irrigation and building water efficiency criteria:

    i. Reduce potable water consumption for irrigation by 50 percent (LEED-NC 2009), Water Efficiency, Credit 1).

    ii. Incorporate strategies that will conserve 20 percent of building water use (LEED NC 2009, Water Efficiency, Credit 3).

Responsibility

Proper implementation of the Measurement and Verification will require active participants from each party associated with the project. UMASS Amherst Facilities & Campus Services (FCS), the Massachusetts Division of Capital Asset Management (DCAM), the University of Massachusetts Building Authority (UMBA), designers, consultants, contractors, subcontractors, commissioning agent and M&V agent shall each have specific responsibilities that will contribute to the development and implementation of the M&V plan. Each Energy Conservation Measure (ECM) will include the ability to measure variables from which an analysis of efficiency, consumption, loads, etc., can be determined. The M&V Agent will have the responsibility of implementing the M&V Plan. The Commissioning Agent (Cx) and the M&V Agent may be the same entity. The M&V Agent shall be an entity independent of the Designer and the Contractor.

Responsible Parties

The M&V agent is the entity primarily responsible for the M&V Plan's development, coordination and implementation. The project owner and building operations staff will support implementation of the plan.

Table 1: M&V Responsibilities

M&V Activity	Responsible Party
Baseline energy model	Designer
Recalibrated baseline energy model to reflect as-built conditions	M&V Agent
Identification of ECMs for inclusion in the M&V plan	Designer/CXA/M&V Agent
Development of M& V plan	Designer
Compilation of all occupancy, controls, and scheduling information during the M&V period	M&V Agent with the assistance of UMA
Spot metering during M&V period (if needed)	M&V Agent
Installation of required sub-metering equipment (this should occur during construction)	Contractor
Installation of Supplemental Data Collection Devices & Equipment and the collection and archiving of performance data	M&V Agent
M&V Report	M&V Agent
Corrective Action Plan	M&V Agent
Corrective Action	UMASS FCS

M&V Methodology

This Measurement and Verification (M&V) plan is based on [enter option used, this will most likely be Option D]: Calibrated Simulation of the International Performance Measurement & Verification Protocol (IPMVP/EVO) Volume Ill: Concepts and Options for Determining Energy Savings in New Construction, April, 2003. The plan is intended to verify the cost savings associated with energy efficiency measures incorporated into the design, and to provide a recalibrated energy model that will serve as a tool for building operators in identifying and remedying causes of underperformance.

This entails the use of an energy simulation model calibrated to predict energy use and determine annual energy savings relative to a baseline building design. Selected points will be monitored through the building automation system (BAS). If any points cannot be monitored using the BAS, independent data logging equipment will be used to capture the necessary data.

The monitored data will be used to:

1. Test and verify the proper functioning of equipment, systems, and controls that impact energy use.
2. Adjust modeling assumptions regarding building operation and occupancy.

3. Determine actual end-use energy consumption and load shape.

Once proper functioning is achieved, the simulation model can be calibrated against measured end-use data to best represent actual performance. The calibrated model is used to determine energy savings relative to the baseline building assuming the same building operation and occupancy.

Sufficient points will be identified for monitoring to perform the functions outlined above. In general, the more vulnerable and high impact energy-efficiency components will be tracked more frequently than the more stable, low impact components. Utility invoices and whole building meter data, permanently installed sub-metering, and spot measurements may also be used to measure the actual utility usage of the building and key end uses for one year of post-occupancy consumption. A detailed list of the metering points is provided in Section 4. An overview of these points is provided below.

The following building systems will be investigated and analyzed during the M&V process to ensure proper operation, sequencing, and scheduling:

Insert list of buildings systems to be investigated and analyzed during M&V

[Some examples are given, please correct, add, or delete for the specific project]

Examples are:
- HVAC components
- HVAC system: interaction of cooling, heating, and comfort delivery systems
- Building Automation System (BAS): control hardware and software, sequence of operations, integration of factory controls with BAS
- Lighting system components

In addition, building conditions pertaining to use and operation will be monitored so that standard assumptions used in the design energy model and the baseline can be adjusted.

These points include:

Insert list of building conditions relative to use and operation that will be monitored

Example:

- Zone temperature set points
- Operating schedules (mechanical equipment, lighting)
- Plug loads
- Fume Hood operation

To reconcile actual energy used to predicted energy use, energy by end-use will be metered. These end uses will include:

Enter list of end energy uses that will be metered

Example:

• Chilled water load
• Steam load
• Air Handling Units
• Pumps
• Lighting
• Supplemental Chillers
• Plug Loads
• Process Loads

It is understood that the sub-metering of lighting, plug loads, and process loads can be a challenge but it is expected that each designer will work to achieve separation of loads and sub-metering within the cost limitations of each project

M&V Tasks

The M&V agent will direct and coordinate the M&V tasks outlined within this plan during the M&V process. This effort should be in union with building facility personnel so they can better assume these tasks beyond the one-year M&V period. Note, however, that model manipulation beyond the one year M&V period is usually not possible without specialized training and experience. Model refinement and updates may be best contracted to [enter name of consultant that will perform M&V model corrections and analysis after the one year M&V period]. Tasks for the M&V agent/consultant will include:

- Assist the building facility personnel to set up the required trends outlined in Table 1, including sampling interval, trending time period, and trend duration.
- Inspect the completed installation of the components outlined in Table 1, and take spot measurements of power, temperature, or flow on selected equipment as necessary.
- Analyze the collected trend data to assess and verify the performance of the components outlined in Table 1.
- Determine adjustment factors and implement these adjustments into the Baseline and Design Models as appropriate.
- Revise and calibrate the Design Model as necessary based on utility billing information as well as the results of the system inspections and trended data analysis to reflect actual building operation.
- Calculate the verified energy "savings" (performance) using the Calibrated Baseline Model and Calibrated As-Built Model.
- Develop a report that presents the results of the investigation, data analysis, and verified energy use and energy saving measure performance. The report should also provide insight into methods to improve energy performance of the building systems.
- Develop a Corrective Action Plan (if needed) and assist UMASS Amherst with the implementation of the necessary corrections.
- Develop materials and train facility personnel to perform periodic inspection (most likely quarterly) of the buildings energy performance.

M& V Period

[UMA, DCAM, UMBA] have contracted with [name of M&V agent] to perform the M&V scope of services described in this M&V Plan. These M&V services will be integrated with the enhanced commissioning services provided by [name of Cx agent] for the [name of project] project. Most of the M&V services will begin once the building is fully occupied and operating under normal operating conditions. While part or all of the M&V services outlined here may be re-contracted and re-applied on an annual basis, the current scope of work will only involve the first year of building operation to satisfy the requirements for LEED EAc5, Measurement and Verification. However, as noted above, this plan includes training to allow UMA staff to continue M&V activities throughout the life of the building.

Equipment Commissioning

Commissioning activities for the project building for the following energy-related systems shall occur during design, construction, and prior to occupancy and shall be conducted by the project's Commissioning Agent (CX) [enter name of project's commissioning agent].

- Heating
- Ventilation
- Air conditioning
- Refrigeration
- Lighting
- Domestic hot water
- Controls
- Elevators
- Building Envelope
    1. Review of Construction Details for air and water tightness.
    2. Monitor installation of envelope elements to conform to Approved Design Details.
    3. Air & Water Tightness Testing as required by the applicable building/energy codes.

Commissioning shall be performed in accordance to LEED EA Prerequisite 1, Fundamental Commissioning and EA Credit 3, Enhanced Commissioning. The Commissioning Report will be included in the LEED certification application, and records of deficiencies and their remediation are kept by the contractor and the Commissioning Agent. Throughout the M&V period, minor additional activities will be performed as necessary by the contractor (during the warrantee period) and the building operations staff. Language requiring the Designer, the General Contractor/Construction Manager and all subcontractors and suppliers to correct contract deficiencies identified by the Commissioning Agent, the M&V agent, or UMASS Amherst during the one year warranty period shall be included in the project specifications.

Project Specifics

Project Description

UMA Project Number and Project Name
Building Number:
Project Address:
University of Massachusetts
Amherst, MA

Please add brief description of the function and scope of the project.

Example:
The new University of Massachusetts [name of project] in Amherst, Massachusetts has been designed and constructed according to [insert LEED or other standard] criteria. The project building is a [xxx] story approximately [xx, xxx] GSF building with a building footprint of [xx, xxx] sq.ft.

Describe the Program & Expected Uses of the project

Project Boundary

The boundary of this M&V plan is the total building energy use (electrical, chilled water, steam, natural gas, water, and renewable energy) of [project name].

Building Type:

Total Square Footage:
(For a detailed breakdown of space types please refer to the program area table in Appendix E)
Number of stories:
Construction Start Date:
Construction End Date:
Estimated Construction Cost:
Total Project Costs:

UMA Facilities Planning Project Manager:
UMA Physical Plant Department Contact:
Designers:

- Architect:
- Mechanical Engineer:
- Electrical Engineer:
- LEED/Energy Conservation Consultant:
- Commissioning Agent:
- Measurement & Verification (M&V) Agent

Owner’s Project Manager (if applicable): Provide Contact Information

General Contractor/Construction Manager: Provide Contact Information

Design

Discuss roles and responsibilities of each party during the design phase of the project.

Construction

Discuss roles and responsibilities of each party during the installation phase of the project.

Commissioning

Discuss roles and responsibilities of each party during the commissioning phase of the project.

Monitoring & Control

Discuss roles and responsibilities of each party during the monitoring and control (trending and reporting) phase of the project.

Building Systems Descriptions

Describe, in detail, the various building systems that will contribute to the building's resource and sustainability performance. Describe how each system will be monitored and data collected to assure desired performance.

Example:
Heat recovery chiller plant
Ventilation energy recovery
Low flow fume hoods
Air quality monitoring system
Radiant floor heating
Water reclamation system
Low flow plumbing fixtures
Daylighting controls
Energy metering systems
Energy Efficient Elevators

Air Distribution Systems

(Describe the projects air distribution system)

Example:
The HVAC system consists of central VAV air-handling units sized at 300 fpm coil velocity providing dedicated tempered outside air. Each unit has steam heating and chilled water cooling coils.

A total of approximately 300,000 CFM dedicated OA is supplied to all spaces through several 100% OA Air Handling units. There is a 3.5 inch W.G. external static pressure (ESP) drop through of the main central AHUs (AHUs 1.1 to 1.1 0). These central units supply air to VAV terminal units serving core lab and office spaces.

Larger lab spaces and areas with higher heat gains have FCU units which re-circulate air. Outside air is supplied through VAV terminal units to the mixing box of the FCUs. This adds an additional 0.5 inch W.G. ESP in the supply air stream. Smaller lab spaces have 100% once through cooling VAV terminal units. All lab spaces are to maintain 6 Air Changes per Hour (ACH) during occupied hours and 4 ACH during unoccupied hours. The Vivarium is supplied 100% OA at the rate of 2.5 CFM/sq. ft. Low flow variable air volume fume hoods are provided for process exhaust. These are assumed to be continuously operating for all occupancy hours. The design capacity of these fume hoods is 450 CFM per fume hood.

Energy recovery is a combination of heat wheel and heat pipe type. Energy recovery on hazardous exhaust is only through heat pipes at a sensible efficiency of 50%. Energy recovery on the remainder of the spaces is enthalpy heat wheel type with 76% efficiency.

Lighting and Process Loads

Provide the projects lighting and process loads per square foot

Example:

Lab Space lighting loads:	1.2 W/ft^2
Open Lab Space Process Load:	8 W/ft^2
Core Space Process Loads:	12 W/ft^2
Office Space lighting load:	0.9 W/ft^2
Process Load for Office:	1.5 W/ft^2

Metering and Sub-Metering

(Describe the meters to be used to record energy & water usage (steam. gas, water, etc.)

Specified Meters shall be the most accurate for the commonly expected flow rates defined for each application.

(Sub-meters are less useful for mechanical systems unless different parts of a building's heating, cooling, and water usage need to be measured)

<u>From UMA Design Guidelines:</u>

"Provide chilled water metering equipment. Meters should be sized to handle the expected maximum and minimum flows and report to physical plant through the Campus energy management system. Turbine meters are favored."

"Provide condensate and steam metering at each building, reporting to the campus energy management system. Meters should be sized to handle the expected maximum and minimum

flows. Vortex meters or orifice plates or annubars with "smart" multivariable transmitters are favored."

"Water supply meters shall read in gallons with electrical contact closure provided for pulse output to remote readout or building automation system, and be flanged and valved with full size bypass to permit convenient replacement. For building meters provide compound type meter to read lowest flow rate. Locate deducting water meters on cooling towers and water cooled devices which discharge directly to storm sewers. Meters shall be high quality with locally available repair parts, Hersey or equal."

MasterSpec section "230519 FL - METERS AND GAGES FOR HVAC PIPING" provides additional guidance for mechanical meters.

Electrical Metering:

[Describe the meters to be used to record electrical energy usage]

From "UMASS Amherst Utility Department Standards, Electrical Distribution & Outdoor Lighting 3.0"

"Electric System Metering/Monitoring:

All Electrical Distribution and Building Service Equipment mains shall be monitored with SQD PowerLogic. Each installation shall include an interface to the university LAN system/ UMass PowerLogic System.

It is recommended that the metering equipment and service equipment be specified separately to maintain competitive bidding on service equipment "

The following additional information is taken from the UMASS Amherst Utility Standards Document

UMass Amherst has adopted Schneider Electric Square D PowerLogic monitors. Monitors are located throughout campus on all electrical distribution feeders and many building electrical services. The system includes Ethernet communication to the campus System Manager Software that is maintained giving consistently formatted monitoring and reporting of power quality, energy and demand.

Metering compartment
(This section must be included with all switchgear specifications. This will allow competitive bidding for switchgear while maintaining our PowerLogic Metering system)

Provide separate customer metering compartment with front hinged door, .2% accuracy current transformer wired to current transformer shorting blocks with shorting pins installed and .2% accuracy potential transformers (where required) or bus taps wired to fuse blocks with disconnect switches as required.

Electric Meters
Electric Metering shall be installed at each Service, Medium Voltage Feeder, Building Service Transformer and separately derived system. Meters supplied and installed shall be as follows:
1. *Generation and Utility Feeds - CM4250*
2. *Medium Voltage Feeders - CM3250*
3. *Science and Data processing - CM4250*
4. *Other Buildings, Generators & Separately derived systems - PM850*

Communication
All meters shall be connected back to the campus System Manager Software server via the campus SCADA monitoring network as follows:

1. *RS-485 wiring (between devices) shall be Beldon 8723 cable with an MCTAS-485 Terminator at last device.*

2. *PowerLogic EGX400 web-enabled Ethernet gateways with two 4-wire serial ports providing Ethernet access to 64 serial devices and connected to campus 10T/100TX Auto network via Campus Tele-Com Department*

Sub-Meters (Electrical):
(Describe how sub-metering and load/space separation will be achieved i.e. lighting, plug loads, process loads, HVAC equipment, etc.)

Building Envelope Specifications:

(Describe the building envelope and provide component and overall U values)

Example:
Building envelope is in accordance with ASHRAE 90.1-2007 specifications and is better than the ASHRAE 90.1-2007 minimum requirements.

Exterior Wall U-Value = 0.052 Btu/h-ft-°F
Roof U-Value = 0.038 Btu/h-ft°F

(How are we commissioning and monitoring & verifying building envelope performance?)

For additional information about the building, please see the project's Owner's Project Requirements and the Mechanical Systems Narrative and the Basis of Design (Appendix A & B respectively).

Campus Central Utilities (Chilled Water, Electric, and Steam)

Describe how the building will utilize the campus' existing district utility services and how these will be treated in the various energy models required for the energy analysis, LEED certification, and the M&V process.

Example:
An existing chiller plant will provide for cooling in the (name of project). All cooling is through chilled water supplied from the remote chiller plant. Chilled water supply temperature is 44 F and condenser water temperature is 85F. The chillers are electric centrifugal type with water-cooled condensers.

All heating is through steam provided by a central steam plant. In addition there is a heat reclaim on the condenser water loop, which provides hot water for reheat coils during summer reheat hours.

Electricity is provided by Western Massachusetts Electric Company (WMECO) and by the campus central heating plant generators.

Occupancy

Describe or graph expected building occupancy patterns

Occupancy Schedules:

Building Standard Occupancy hours are:

Building Standard Occupancy days are:

Enter campus schedule here (including holidays and other days when the campus is closed) Include the academic schedule as it relates to the building.

Occupant Education and Behavior:

Describe the project's goals and procedures to educate and influence the occupants as to the use of energy conservation features and building elements.

Building Automation System

(Describe the Building Automation System (BAS))

Example:
The building automation system (BAS) will consist of a direct digital control (DDC) system. This system will allow the operator to input set point parameters, monitor equipment status, access data points, create trend-logs, monitor alarm points, monitor equipment run time, etc. The BAS will have the ability to perform optimum start/stop. The DDC controls will be networked to the campus central system. Equipment components and points to monitor are presented in Table 1 of sec. 4.2.

(Describe how the various mechanical and electrical meters will connect to the BAS)

Energy Conservation Measures (ECM's)

(Describe the project's energy conservation measures)

Example:
Multiple ECM's were implemented during the design phase of the project. The building automation system will monitor and control individual spaces to determine when each strategy is implemented as well as provide performance feedback. Operation parameters of ECM's will notify/alarm building operators of conditions that may adversely affect energy savings performance. The ECM's included in the design are:

A sample list of ECM's is presented below:

Roof Insulation
Wall Insulation
Slab Perimeter Insulation
Infiltration Rate (Perimeter/Core)
Shell Glazing Properties (U factor, SHGC)
Lighting Power Density by Activity Area
Misc. Equip Power Density by Activity Area
Static Fan Pressure
Cooling Efficiency
Heating Efficiency
Boiler Efficiency (HW systems only)
Economizer Control
Primary and Secondary Loop Pump Controls
Supply Air Temperature Reset (VAV systems only)
VAV Fan Control (VAV systems only)
Demand Controlled Ventilation
Daylighting Controls
Occupancy Sensors
DHW System Efficiency

Building Envelope

(Describe Energy Conservation Measures Utilized in the Building Envelope)

Lighting

Please provide description of any relevant lighting energy conservation measures.

Lighting ECM's should comply with ANSI/ASHRAE/IESNA 90.1-2007.

HVAC

Energy Recovery
Please provide description of any relevant energy recovery energy conservation measures.

Air Economizer
Please provide description of any relevant air economizer energy conservation measures.

Motors & Variable Frequency Drives (VFD's)
Please provide description of any relevant motor or variable frequency drive energy conservation measures.

Air Distribution
Please provide description of any relevant air distribution energy conservation measures.

Please provide description of any relevant energy conservation measures not described in the previous categories.

Other Energy Conservation Measures

ECM Not Covered in Previous Categories (ex. Central Chiller Plant vs. Local Chiller)

Annual Savings

Initial annual energy savings for this facility were estimated by…Please describe how the initial energy savings were estimated.

The following table summarizes the savings expectations resulting from the energy conservation measures designed for this project. A more detailed breakdown of the savings can be found in Appendix F.

Table xx Expected Annual Energy Savings

Energy Type	Baseline Annual Consumption (kBtu)	Projected Annual Consumption (kBtu)	Projected Annual Savings (kBtu)	Projected Annual Cost Savings ($)	Percent Cost Savings
Building Integrated or Building Mounted Renewable (Solar or Geothermal)					
Electricity					
Steam					
Chilled Water					
Natural Gas					
Total					

The expected annual consumption values above will be adjusted based on weather data, occupancy levels, and system operating parameters realized during the year-long period during which energy consumption measurements are in place. The adjusted expected savings will then be compared to actual savings.

Table xx Expected Annual Energy Savings

ECM	Energy	Electrical	Energy	Total Annual	Percent Annual
	Type	Savings	Savings	Cost Savings	Energy Savings
		[KWH]	[MM Btu/hr]	[$]	
Lighting					
Space Heating					
Space Cooling					
Pumps					
Fans					
Other					
Other					
Total Savings:					

Methods

Describe methods for calculating energy savings (equations, definitions, metering).

Assumptions

The following assumptions were made in the final energy analysis model for the facility name:

Describe assumptions made in the final energy model?

Example:

- People, Lighting, and Equipment Schedules
- Outdoor Air Delivery
- Heat Gain
- Building Envelope
- Other

Energy Savings Calculations

As presented in IPMPV Option D, Method 2, energy savings in new construction M&V are determined by comparing actual post-construction energy use to the projected energy use of a baseline under similar operating conditions. In general:

Energy Savings = Adjusted Baseline Energy Use - Post-Construction Energy use

The adjusted baseline energy use is determined from the baseline model with standard assumptions updated to reflect actual operation (weather, schedules, set points, etc.). Post construction energy use is based on utility billing data, and building level metered data.

The adjustments applied to the baseline model reflect actual conditions observed on site. These adjustments come out of the calibration process. Calibration involves comparing performance estimates determined for the as-built building model with actual utility billing data. Calibration is complete when the modeled as-built performance reflects actual performance within accepted tolerances per ASHRAE Standard 14-2002. Calibration includes making refinements to the modeling input assumptions based on operating conditions (adjustments) and actual equipment/system/controls operation as determined through monitoring. Thus, adjustments to operating conditions apply to both the baseline and as-built models. However, modeling refinements made to correct for actual performance of systems and components apply only to the as-built model. More details about modeling and calibration procedures are outlined below.

Monitoring and Control

The Building Automation System (BAS) includes network components for each of the major systems included in the ECM as previously described. Data from the following system will be utilized for savings and adjustment calculations.

Describe the BAS Sequence of Operations for this project.

Lighting

Describe the monitoring and control strategies for lighting.

HVAC

Describe the monitoring and control strategies for HVAC.

Energy Recovery Systems

Describe the monitoring and control strategies for energy recovery systems.

Air Economizer

Describe the monitoring and control strategies for air economizer.

Motors & Variable Frequency Drives (VFD's)

Describe the monitoring and control strategies for motors and variable frequency drives.

Air Distribution

Describe the monitoring and control strategies for air distribution.

Heating and Cooling Loads

Describe the monitoring and control strategies for heating and cooling loads.

Domestic and Irrigation Water

Describe the monitoring and control strategies for domestic and irrigation water.

Monitoring System Point List

Insert BAS Monitoring Points List

Meters Interval Value

Insert the metering interval value for each type of meter (should be no more than 15 minutes)

BAS Data

Insert a description of the BAS system data retrieval and storage methodologies

Other Information

Global Data

Insert other data used, such as weather, occupancy, etc.

Baseline Strategies

Discuss methods for developing baseline model. Examples include:

- Simulation Software
- Variables Affecting Baseline Accuracy
- Adjustments Made to Baseline (calibration)
- Other

Utility Rates

The utility rate information used for the energy savings calculation will not need to escalate to account inflation. Non-inflated values will help insure all savings calculations are minimum (based on the assumption that utility rates do increase based on inflation). Energy prices used in baseline data are based on (one year) for the University of Massachusetts Amherst.

Utility Resource	Metered	Rate	Adjustments
		($/Unit)	
Renewable (identify)			
Electricity			
Chilled Water			
Steam			
Natural Gas			
Other			
Other			

Energy Models

Pre-Construction Models

As part of the LEED certification process, an eQuest hourly building energy simulation of the building was created to model current design specifications and predicted operating conditions. This represents the building pre-construction **Design Model.** This pre-construction Design Model was then adjusted to reflect the minimum energy performance requirements of ASHRAE 90.1-2004. This adjusted model represents the pre-construction **Baseline Model.** The building energy use for the pre-construction Baseline Model and the pre-construction Design Model was calculated using the eQuest model; the energy use difference between these two is the predicted energy savings and is the basis for EA credit 1. Note, however, that this pre-construction baseline is theoretical and based on standard operating assumptions during design.

Described below is a process for adjusting this baseline to better reflect actual operating conditions.

Example:

Post-Construction Models

During building construction and through the commissioning process, the M&V activities include working with the controls contractor to ensure that the BAS will trend the necessary data. This will also involve coordination with the commissioning agent regarding analysis of trend data collected during the commissioning process and visual inspection of the installed components.

Once construction of the building and commissioning is complete, and the building is operating under normal operating conditions, the M&V Plan is implemented. The conditions of operation during the M&V period are reviewed and necessary adjustments are made to the post-construction Design Model so it reflects actual operating conditions. Adjustments can include occupancy parameters, schedules, equipment performance and/or system control. Then the TMY (Typical Meteorological Year) weather data used for the pre-construction Design Model is corrected to reflect the actual weather conditions during the M&V period. The model is now the **As-Built Model.** Similarly, these adjustments where applicable are applied to the Baseline Model yielding the **Adjusted Baseline Model.**

Calibrated Models

During the M&V period, performance data are collected, usually through the BAS at 15 minute intervals throughout the year. If any information is not available through the BAS, portable data loggers will be used. Data collected through these loggers will be at intervals necessary for accuracy and appropriate to the modeling software. The As-Built Model is run and the results compared to the measured, post construction energy use, collected during the M&V period. Variances are investigated and inputs are refined as described in the IPMVP so the simulation is in calibration with actual operating conditions. Ranges of error for acceptable calibration are in accordance with ASHRAE Standard 14-2002, Table 5-2. This calibrated model is the **Calibrated As-Built Model.**

Finally, the input adjustments made in the Calibrated As-Built Model are applied to the baseline model to improve the accuracy of this baseline energy projection. This is the **Calibrated Baseline Model.** This allows the actual energy performance of the building to be measured and the building end-uses can be established. This process is illustrated in the diagram below.

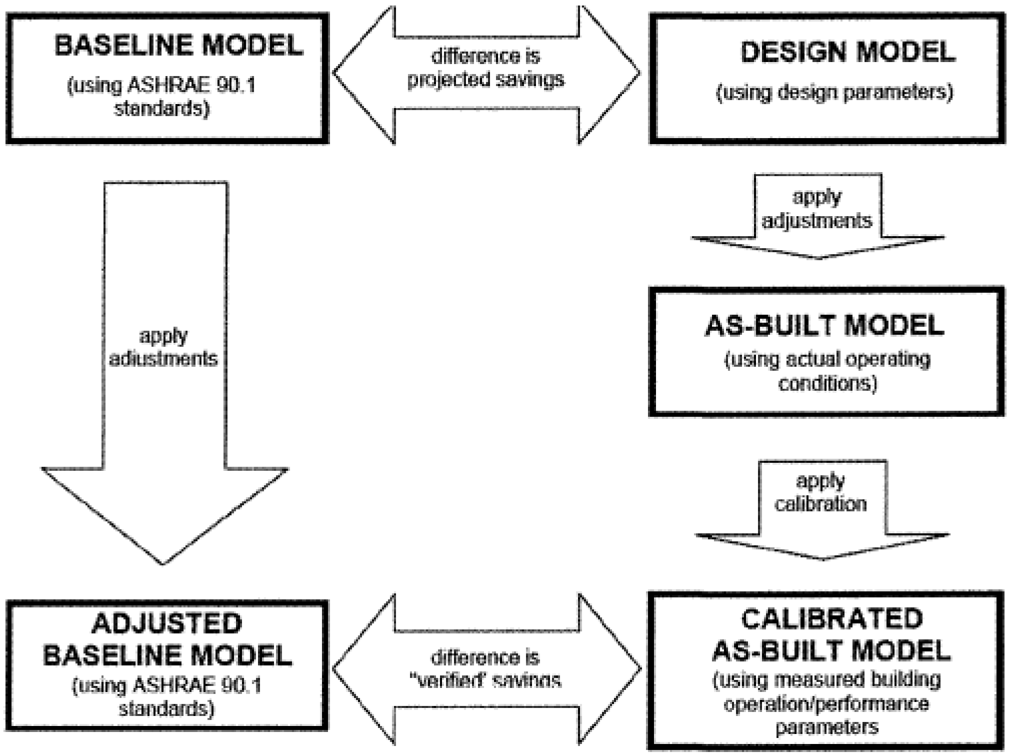

Figure 2 – Energy Model Calibration Flow Diagram

Weather Data

The appropriate typical meteorological year (TMY) weather data set for Amherst, Massachusetts, was used in the eQuest simulation for design. This weather data was collected from NOAA's National Climactic Data Center, and represents average weather conditions for the region over a thirty-year period.

The actual weather data, collected from BAS sensors during the M&V period, will be used for the Calibrated As-Built Model and the Calibrated Baseline Model.

Visual Inspections

Visual inspections of lighting fixtures and controls, as well as HVAC equipment characteristics and controls will be performed. These observations will be incorporated into the eQuest model as necessary, to verify predicted energy performance.

Monitoring and Analysis

Monitoring will be performed on a variety of system components using the BAS for the full one-year M&V period. Points that cannot be trended using the BAS will be monitored using independent data loggers at an appropriate time and interval. All data (trended and logged) will be collected at the same sampling rate to allow for easy comparison of data streams and subsequent analysis of equipment performance and operation. These monitored points will help to assess the actual operation of the building's general components and specific system Power will be measured for all major pieces of equipment. For constant speed motors, spot measurements of power will be combined with monitored motor status, to calculate electric consumption. Similarly, for motors equipped with VFDs, spot measurements of power will be taken at a number of various motor speeds. VFD status and speed will be monitored and combined with the spot measurements to calculate electric consumption.

For lighting fixtures, current for whole lighting panels or individual lighting circuits will be monitored to calculate associated lighting load shapes. Plug loads will be monitored in a similar fashion. Energy will be measured for central plant steam and chilled water.

Trending and Data Collection

Trends will be used to collect data for model calibration and energy use calculation but also to monitor the function of systems to insure they are operating efficiently and meet the design intent. Trends to monitor the function of each primary system (such as chilled water, steam, heating hot water, air handling units and lighting) will start near the end of commissioning activities. These trends will be used for diagnostics and continue until the systems have normalized indicating building function and use are stable. Normalization indicates the M&V period can begin, and trends and data collection for model calibration and energy use calculation will start. These trends and hourly data collection will continue for one (1) year of normal 'stable' occupancy and operation of the building. Trends will be analyzed and there will be visual inspection of equipment and controls during this process. When trend analysis and/or energy calculations indicate a problem, we will select additional points for diagnostic trending components.

Training and Ongoing Accountability

Although the M&V agent will only perform detailed M&V services for the first year or two of stable operation, facility personnel will be trained, and materials developed, that will allow facility personnel to periodically check on the building's energy performance through additional M&V periods in subsequent years. These materials will be based on observations made during the initial M&V effort, and will empower facility personnel to check trend data, perform targeted functional performance tests, and to identify any changes in the energy performance of the building that may warrant scrutiny. However, changes in the building systems, changes in the building use, or changes in the building itself (additions or significant renovation) will require adjustment and recalibration of the building model and specialized training.

Quality Assurance

Use of the same eQuest building energy simulation model and base assumptions for the Design Model and Calibrated As-Built Model energy savings calculations will allow for accurate comparison of the predicted and verified energy savings. Using this option also allows for complete control over general assumptions; including lighting and plug load densities, equipment and occupancy schedules, and system control set points. Using actual weather date for the Calibrated As-Built Model instead of the normalized TMY weather data of the model is necessary for the calibrated model to reflect real world operating conditions.

The M&V strategy will be reviewed following the first month of implementation to ensure that procedures and processes are effective for capturing the required data. Monthly data recordings will be reviewed promptly for anomalous values that could signal data errors or underperforming equipment.

M&V Report

An M&V report will be presented to UMA and DCAM, the building owner that describes the results of the monitored data analysis, and presents the energy performance results and building end-uses. The M&V Report will also include recommendations that may improve energy performance if the building is not performing as expected. The report will be reviewed between TBA and DCAM and UMA facility personnel, to provide clarification of any of the items or observations in the report.

In addition to presenting the true energy performance of the building, the report will present the energy performance of the different end-uses, using the output files from the energy models. Energy use for the end uses will be reported in both MBtu, as well as energy units appropriate for that end-use. The end uses will include:

- Chilled water use for cooling
- Lighting
- Steam use for heating
- Miscellaneous plug loads
- Air distribution & ventilation system
- Energy use for domestic hot water
- Pumps
- Exterior equipment and lighting

Budget and Resources

UMA/DCAM/UMBA are financially responsible for providing for the M&V program costs. Materials and labor budgets are outlined below. These do not reflect soft costs associated with data recording on the part of the operations staff.

Item
Sub-metering Equipment
M&V Labor
Corrective Action

Budget
$
$

As Needed

M&V Activities

M&V activities required for this project include activities for each of the 3 phases of this plan.

Activity cost for the Pre-installation and Post-installation are rolled up in the total new construction cost for the overall building design.

Annual activities are to be performed by the M&V Agent for the 1st year and by University of Massachusetts Amherst PPD personnel for subsequent years.

Commissioning and M&V services are required to review data collected from the first full year of facility operation. Certain elements of the 1 year post occupancy commissioning process take place at the 10 months after occupancy so that UMASS can require corrections under the standard 1 year construction warranty.

Schedule & Reporting Activities

Describe the scheduling and reporting activities of the measurement and verification plan.

Construction Activities

Describe the installation activities of the measurement and verification plan.

Review of warranties -------→ 10 month Cx activity

Post-occupancy Activities

Describe the post-installation activities of the measurement and verification plan.

Commissioning at 10 months (because we have 1 year warranties on most items)

Annual Activities

Describe any activities that shall be conducted annually as per the measurement and verification plan.

Annual Summary Report

To be generated after annual activities. Report should include data collection from BAS, adjustments made as a result of the data collection, and summary of annual energy savings.

Reports are to be sent to

[Enter the name of the person who should receive these reports]

Appendix A – Owner's Project Requirements (OPR)

Attached the Owner's Project Requirements (OPR)

Appendix B - Mechanical Systems Narrative and Basis of Design (BOD)

Attached the Mechanical Systems Narrative and Basis of Design (BOD)

Appendix C – UMASS Campus Design Guidelines

Designers and Project Managers must refer to the UMASS Amherst Design Guidelines for all projects.

The guidelines were developed to present the University's preferences and criteria for the design and construction of campus facilities and landscape.
The goal of the design guidelines is to improve the overall aesthetic character and visual unity of the Amherst campus as a whole. They represent the University's commitment for future buildings to create a more cohesive, attractive, productive and sustainable campus environment. The following guideline documents are available in PDF format:

Green Building Guidelines

Construction Design Guidelines

Utility Department Standards

UMass Amherst Campus Signage Guidelines

UMass Amherst Campus Landscape Design Standards

UMass Amherst Climate Action Plan

Audio-Visual Program Guidelines

UMass Amherst Room Numbering Guidelines

http://www.umass.edu/fp/projectmanagement/designguidelines/

See the next page for the required building meters at UMASS Amherst.

Steve Grden
Metering and Controls Engineer
Physical Plant Building
360 Campus Center Way
Amherst, MA 01003-9248
Phone: (413) 545-3657
sgrden@facil.umass.edu

Physical Plant Division

To: General Contractors

From: Physical Plant Utilities

Date: October 12, 2011

Re: New Building Construction Metering Standards.

The following describes the metering standards for all new buildings over 20,000 square feet, for the Amherst Campus. The four meters are incoming electrical service, incoming steam flow, incoming water consumption, and condensate water return. Details of each follow.

1. **Electric Meter.** Each main electrical service shall incorporate a Square D, Powerlogic electric metering system. This system shall include revenue grade current transformers and potential transformers. The metering system shall include a Square D, Ethernet gateway to allow the electric meter to be connected to the campus's local area network. The contractor is responsible to supply and install all this hardware. The minimum meter for any new building shall be a Square D, PM850, science and lab buildings shall use a CM4250. Any other lower level meters shall be approved by, in writing by the Physical Plant Utilities Department.
2. **Steam Flow Meter.** Each steam pipe coming into any new building shall have a Rosemount 3095 multi-variable, differential pressure, orifice plate style, temperature compensated steam flow meter installed. The contractor shall install and connect to the buildings Johnson Controls building automation system via a 4-20ma signal, proportional to steam flow. The steam flow meter shall be installed in an easily accessible area for maintenance and regular scheduled calibration by a technician. The steam flow meter shall have a local instantaneous readout, and have a local totalizer readout. The instantaneous flow units are in lbs./hr., the totalization is in lbs.
3. **Condensate Return Meter.** Each main condensate return line out of the building, shall have a Rosemount, bi-directional, mag-flow water meter. The contractor shall install and connect to the buildings Johnson controls building automation system via a 4-20 ma signal, proportional to water flow. The condensate return meter shall be installed in an easily accessible area for maintenance and regular scheduled calibration by a technician. The condensate return meter shall have a local readout for instantaneous, and totalization values. The units are in cubic feet.
4. **Water Meter.** Each water input location shall include a Hersey Water Meter. The water meter shall be installed by the contractor and connected to the Johnson Controls building automation system. The register shall provide an electrical contact closure pulse to to JCI system. The meter shall include a main, and bypass flow local reading, and both should be connected to the building automation system. The units are in cubic feet.

Appendix D - Building Occupancy Schedules

Insert schedules describing the building's occupancy schedules

Appendix E - Building Program and Spaces

Insert descriptions and plans of building program and spaces

Appendix F - Additional Breakdown of Energy Consumption Data

Additional Breakdown of Energy Consumption Data						
Month	**Electricity**		**Heating Hot Water / Steam**		**Chilled Water**	
January						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
February						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
March						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
April						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
May						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
June						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
July						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
August						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
September						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
October						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
November						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
December						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons
Totals						
Consumption		kWh		MBTU		ton-hr
Peak Demand		kW		MBTU		tons

Load*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
Interior Lighting													
kWh													
Max kW													
HVAC (other than Pumps or Fans)													
kWh													
Max kW													
Pumps													
kWh													
Max kW													
Fans													
kWh													
Max kW													
Domestic Hot Water													
kWh													
Max kW													
Plug Loads & Other													
kWh													
Max kW													
Exterior Lights													
kWh													
Max kW													
Totals													

*Provide further breakdown and more detail if needed