UMass Chan Medical School

Office of Facilities

Energy Modeling Guidelines

Design Technology Group

March 2026

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OVERVIEW

1.1 EXECUTIVE SUMMARY

- University of Massachusetts Chan Medical School (UMass Chan) has determined that energy modeling is the best method to accurately estimate the energy use of a facility and determine a realistic performance benchmark. As part of UMass Chan's sustainability and life cycle cost standards, the results from energy models will be used (internally by UMass Chan) to estimate greenhouse gas emission impacts for all renovation and new construction projects.
- The objective of this modeling guideline is to produce estimated projections of energy consumption that are consistent between projects, are more representative of eventual metered utility data, and can be used in a variety of ways based on the project's needs and scope. The goal of these guidelines is to ensure that energy modeling activities undertaken by the design team are used to inform the design process, and then, once construction is complete, it can be used to retro-commission the system to maximize performance and minimize energy consumption.

1.2 RELEVANT RESOURCES

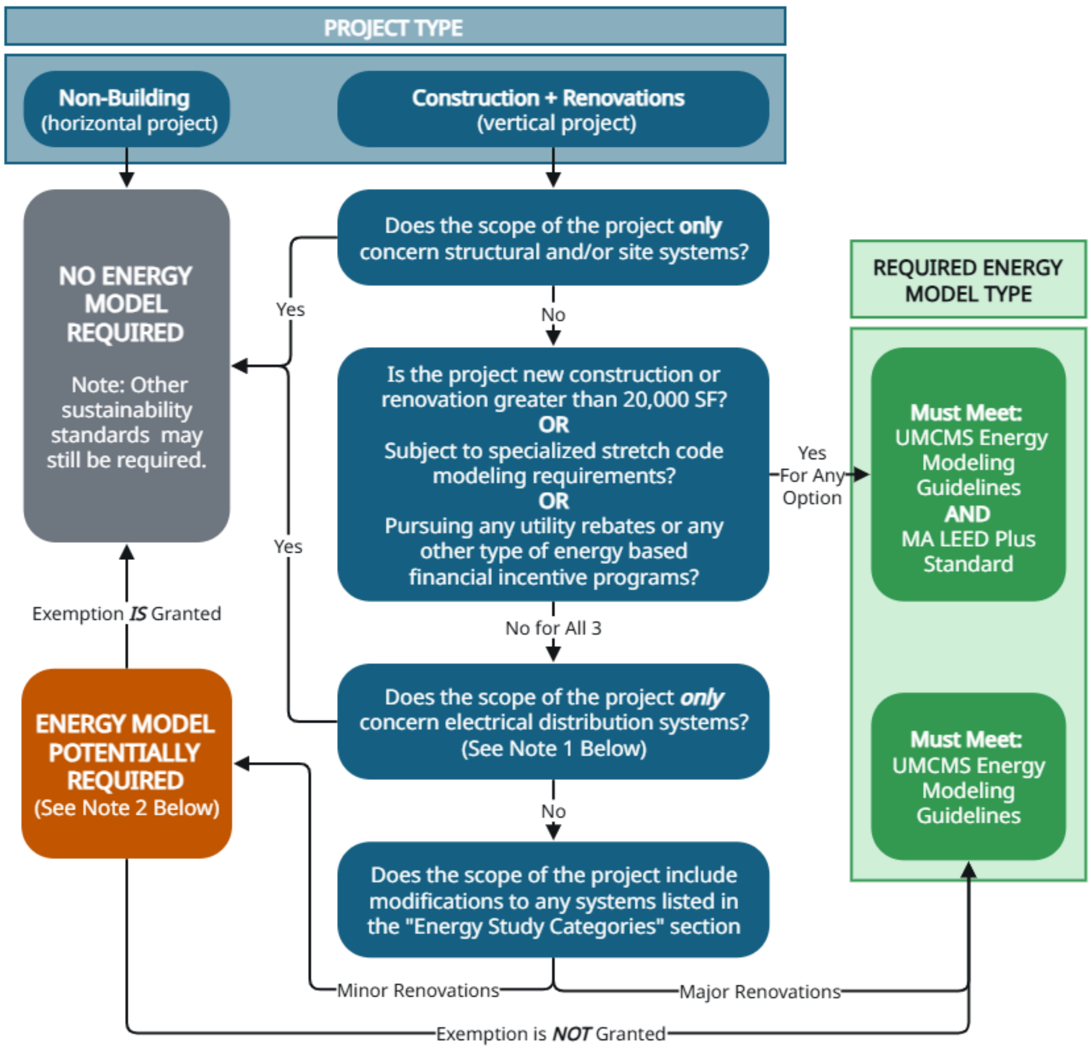
The following resources relevant to energy modeling are referenced within this document.

RESOURCE	DESCRIPTION	REQUIREMENT
UMass Chan Medical School Documents	Relevant UMass standards and guidelines: Sustainability & Resiliency Standards Life Cycle Cost Analysis Guidelines Proposed Energy Consumption Spreadsheet	Required
Executive Order 594	Massachusetts Governor Executive Order for all buildings in use by state agencies or on state lands. Sustainability requirements for all new construction or substantial renovations. Includes requirements for existing building energy efficiency upgrades and decarbonization.	Required
ASHRAE 140	Standard for the performance evaluation of Building Energy Analysis Computer Programs. All energy modeling software must meet this standard.	Required
ASHRAE 90.1	The benchmark for energy efficiency in commercial buildings. Referred to in International Energy Conservation Code (IECC) and LEED. Appendix G: "Performance based compliance" especially relevant to energy modeling.	Code requirement
LEED Standard	Leadership in Energy and Environmental Design Standard. The American sustainability standard for building design.	Required for projects >20,000sf
LEED v4.1 Minimum Energy Performance Calculator	Published by the U.S. Green Building Council and is available for free download at the following website address: https://www.usgbc.org/resources/leed-v41-minimum-energy-performance-calculator	Required
Energy Plus Weather Files	Energy Plus is an open-source energy simulation program developed by the Department of Energy. Energy Plus provide weather files from around the globe, available here: https://energyplus.net/weather	Required

Figure 1: Relevant Resources

WHEN IS AN ENERGY MODEL REQUIRED

➔ Project teams must first determine when it is appropriate to conduct an energy model. The fol-lowing decision tree is helpful in guiding the project teams through whether an energy model is *required:*



Notes:

1. Projects identified as only concerning "electrical distribution systems" are projects like switchgear upgrades or generator replacement. Essentially, these impact how energy is distributed through the building but cannot be modified to reduce the end use consumption of energy.
2. A request for an energy model exemption must be made to the Office of Sustainability & the Design Technology Review Committee (DTRC).

Figure 2: Energy model decision tree

2.1 ENERGY STUDY CATEGORIES

➔ For the purpose of determining the relevance of an energy model to a project, there are the five (5) general categories: Energy Systems, Mechanical Systems, Electrical Systems and Building Envelope. Any impactful changes proposed to these systems may necessitate an energy model. The following figure lists examples of design options under each category that may be explored in an energy *model.*

ENERGY SYSTEMS

1. Central plant-connected vs. stand-alone system (steam and chilled water)
2. Alternative energy systems (e.g., solar photovoltaics, solar thermal, heat pumps)
3. Equipment options for stand-alone systems (e.g., air-cooled chillers vs. refrigerant- based direct expansion [DX] units)
4. Ground source heating and cooling systems (e.g. geo-exchange, geothermal)

MECHANICAL **SYSTEMS**

1. Air distribution systems (e.g., variable volume vs. constant volume, overhead vs. underfloor)
2. Water distribution systems (e.g., various piping systems and pumping options)
3. Heat recovery systems (e.g. heat recovery chillers, air-side heat recovery)

ELECTRICAL SYSTEMS

1. Indoor lighting sources and controls
2. Outdoor lighting sources and controls
3. Receptacle and process load sources and controls

BUILDING ENVELOPE

1. Exterior wall construction and insulation options
2. Roofing systems (various materials and insulation methods)
3. Fixed shading options
4. Fenestration systems (e.g. windows, skylights, curtain-wall systems, electromic glazing)

PLUMBING

1. Domestic Hot Water heating system options (e.g., air-sourced heat pumps, instantaneous point-of-use units, water to water heat exchanger with mechanical systems)

Figure 3: Energy Study Categories

ENERGY MODELING REQUIREMENTS & METHODOLOGY

3.1 WEATHER FILE REQUIREMENTS

- ➔ Each energy model shall use the “Worcester Rgnl AP 725095” TMY3 weather data.
- ➔ See *Figure 1: Relevant Resources* for acceptable weather file sources.

3.2 ENERGY MODEL TYPES

- ➔ Under the scope of this standard, the energy modeler could be required to generate up to three unique energy models for a project; proposed, baseline-existing and baseline-LEED. These categories have been provided to afford regulatory and design comparisons where necessary. Each deliverable should list the model type under one of these categories. Multiple design options will naturally lead to multiple proposed models.

Proposed

Energy model incorporating the proposed design elements
May include mutiple models with proposed design options.

Baseline - **Existing**

For projects with existing buildings being renovated.
Incorporate the existing building systems as they stand at the start of the energy modeling study.

Baseline - LEED

A hypothetical building for the purposes of comparing the proposed deisgn to the worst case version of the design which in this case is a facility meeting the minimum requiremnts of ASHRAE 90.1 Appendix G.
A requirement of all LEED projects. This model Cannot be used for the "Baseline - Existing" Model.

Figure 4: Energy Model Types

3.2.1 INTELLECTUAL PROPERTY RIGHTS

- ➔ Upon completion of each project the final energy modeling file(s) (including associated files and/or file directories required for a complete simulation) required by these guidelines will be delivered to the Owner. The files will become property of the Owner and will be made available to any of the Owner’s contractors and consultants upon request.

3.3 PROPOSED ENERGY CONSUMPTION SPREADSHEET

➔ The Proposed Energy Consumption Spreadsheet requires the energy modeler to provide a full year of hourly simulation results (8760 hours) meeting the following requirements:

1. Provide that energy consumption data in excel format.
2. Provide energy consumption data for each energy source.
3. Provide energy consumption data for each energy end use (separated by energy source):
    a. Interior lighting,
    b. Exterior lighting,
    c. Internal equipment loads,
    d. Service water heating equipment,
    e. Space heating,
    f. Space cooling,
    g. Heat rejection equipment,
    h. HVAC fans,
    i. HVAC pumps,
    j. Elevator equipment,
    k. Any other relevant energy end use, such as specific process loads
4. All energy values will be in kBTU/hr.
5. All demand values will be in kBTU.
6. No calculation of energy cost or carbon emissions is required.

3.4 LEED CALCULATOR

➔ The LEED calculator will be a living document throughout the entire project. This document will be continuously updated by the energy modeler and made available to the Owner as required for review. Depending on the Energy Model Type(s) the following separate spreadsheets could be required:

1. **Proposed Spreadsheet:**
    a. This spreadsheet will contain the ***Proposed*** energy model and the ***Baseline-LEED*** model (where applicable).
2. **Existing Conditions Spreadsheet**:
    a. The ***Baseline–Existing*** energy model will be document in a separate, , independent LEED calculator spreadsheet. No LEED baseline inputs shall appear in this spreadsheet, as they will likely differ from the actual existing conditions.

See *Figure 1: Relevant Resources* for calculator source.

3.5 ENSITIVITY ANALYSIS

- A sensitivity analysis is useful in comparative analysis to determine which design parameters have the greatest impact on building energy performance. However, in design-phase predictive energy modeling, a sensitivity analysis is also useful in determining the probable range of performance outcomes due to the uncertainty in the construction and operation of the building and its systems. It also provides the building operator with a list of parameters to monitor closely.
- This analysis typically starts with a proposed energy model, typically using standardized or as-designed inputs. One or more sets of simulations are executed that provide information about the sensitivity of annual building energy use to specific design or operational parameters. These parameters can be properties or sets of properties relating to building design or operation that can vary continuously or discretely over a range of values. Examples of possible parameters include, but are not limited to, the following:.
    1. HVAC and lighting control set points and schedules
    2. Occupants and schedule of occupancy.
    3. Receptacle equipment loads and pattern of energy consumption.
    4. Infiltration rate.
- Sensitivity is the change in building energy use per change in the given parameter; for instance, a 10% increase in plug loads may produce a 1% increase in site energy, and responses may not be linear across the range of inputs. The energy modeler may choose their preferred approach to performing this analysis. The following are suggested methods that the energy modeler can also utilize if desired:
    1. One approach is to perform several simulations over a range of parameter values. The building energy use can then be extrapolated and interpolated to be plotted as a function of the given parameter. The resulting curve gives an idea of the relationship between the given parameter and energy use.
    2. A less rigorous approach to sensitivity analysis that may require fewer simulation runs is to compare the baseline energy use to only two additional data points. The two simulations bracket the original parameter value by increasing it by a fixed value (e.g., 50%) in one run and decreasing it by the same value in the other run. The slope between the two extremes provides a measure of the sensitivity. This slope can be used to interpolate energy savings for intermediate parameter values.
- In either of the two approaches to sensitivity analysis, caution should be exercised when selecting the endpoints of the range and the intermediate values to test, as the relationship between a parameter and energy use may not be linear over a broad range.
- Once the parameters having a high level of sensitivity and uncertainty are identified, one or more simulation runs should be performed using a combination of different values for these parameters across their probable ranges. The number of runs and the values of each parameter within each run may be determined through automated/scripted batch

processing of all possible combinations or a smaller set of simulation runs in which the value of each parameter is randomly selected within its probable range. The results of these simulations will provide a range of predicted building performance that can be used to inform design decisions.

3.6 DESIGN OPTIONS

➔ When applicable in the energy modeling phase, the project should follow the standard methodology for exploring design options outlined in the Life Cycle Cost Analysis (LCCA) Guidelines.

3.7 MODEL APPROVAL PROCESS

➔ This flow chart provides a clear, visual representation of the steps involved in the energy model approval process. It also facilitates efficient communication and coordination among departments. By standardizing this process, we can make more informed, sustainable, and financially sound decisions that align with our campus's long-term goals.

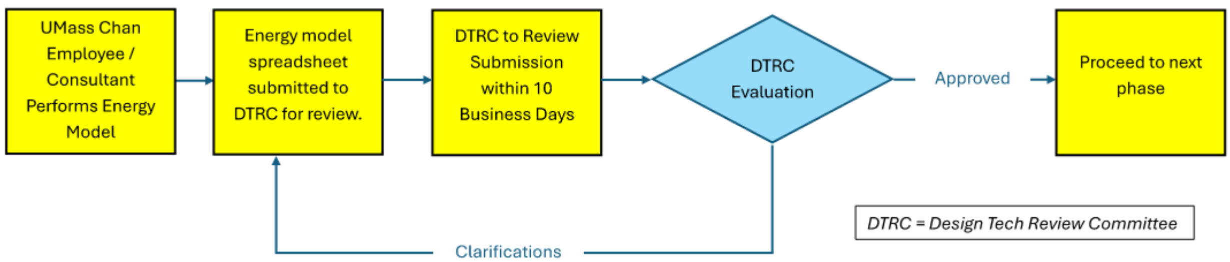


Figure 5: UMass Chan Approval Process

➔ At each review stage (defined in Energy Model Workflow chart in *Figure 7* and *Figure 8*: *Energy Modeling Process Workflow*), the Owner will fill out and complete standard comment review form (see <u>Figure 9: Sample Energy Modeling Workflow Checklist).</u> The energy modeler shall address the comments or provided responses for discussion with the reviewer.

ENERGY MODELING PROCESS PHASES

➔ The UMass Chan process includes the following framework to complete an effective energy model. The process example below is based around a typical project development progression and should be adapted to meet the unique needs of individual projects. A workflow with review stages is provided in *Figure 7* and *Figure 8*: *Energy Modeling Process Workflow*.

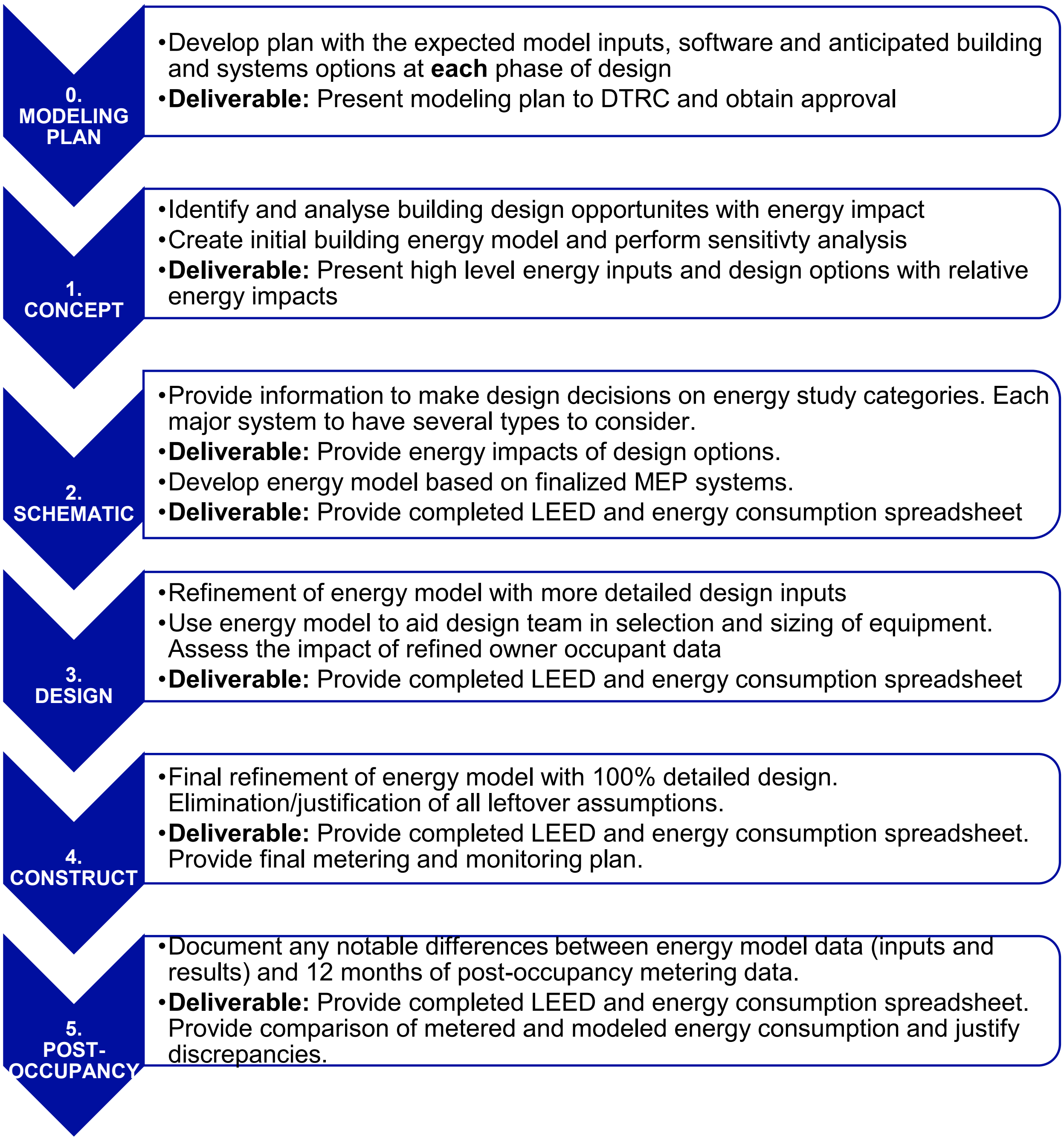


Figure 6: UMass Chan Modeling process framework

4.1 ENERGY MODELLING WORKFLOW

4.1.1 DESIGN PHASES 0 THROUGH 2

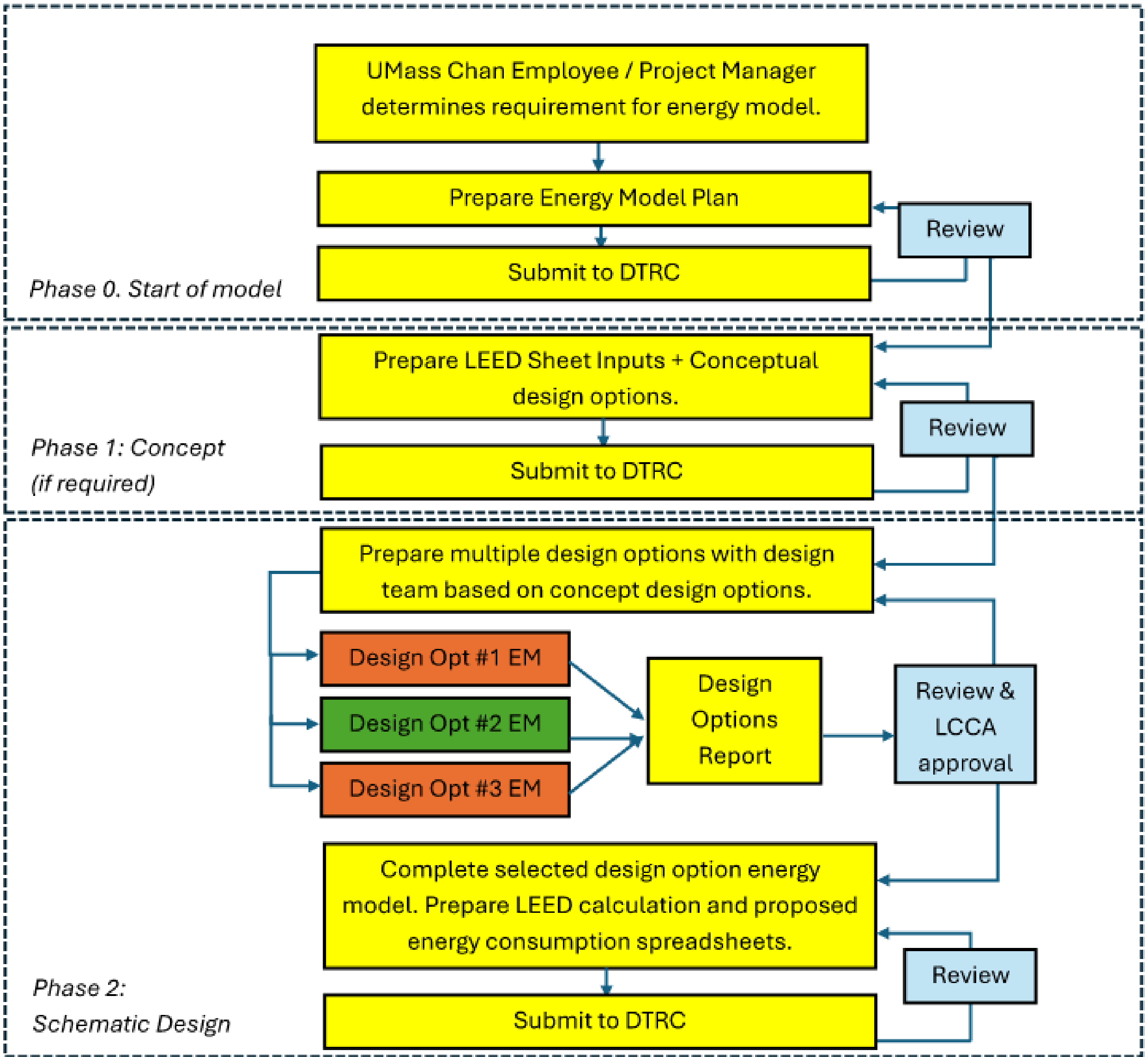


Figure 7: Energy Modeling Process Workflow Chart (Phase 0 through 2)

4.1.2 DESIGN PHASES 3 THROUGH 5

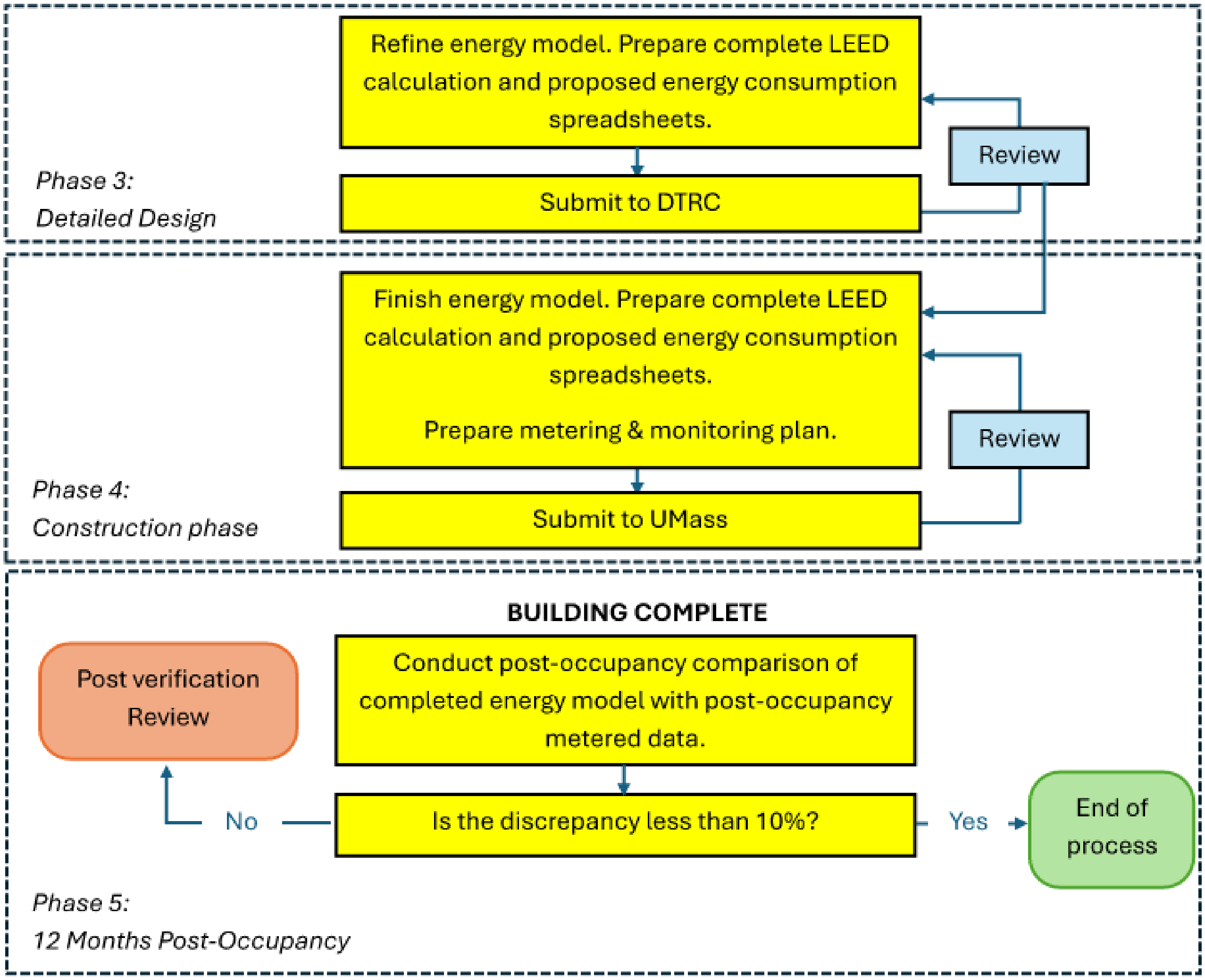


Figure 8: Energy Modeling Process Workflow Chart (Phase 3 through 5)

4.2 PHASE 0: ENERGY MODELING PLAN

➔ **Objective:** Prior to the start of modeling, the consultant shall present an energy modeling plan that describes the intended modeling approach to be used throughout the course of design.

➔ **Final Deliverables:** Upon completion of this phase the energy modeler is to provide the following documentation for the Design Tech Review Committee (DTRC):

1. An energy modeling plan defining the following for each phase of design:
    a. Model inputs that are anticipated to be known or assumed at that point of design.
    b. Modeling software to be used.
    c. The anticipated building and system options that will be evaluated at each phase.
    d. Any of the following phases or major elements of the phase that are to be excluded from the process.

4.3 PHASE 1: CONCEPT PHASE

➔ During this stage of a project the building's geometry, envelope, and site orientation have been set in the design process. This phase is not always included in a project timeline and therefore may not be a requirement, should this be the case it must be included in the energy modeling plan.

➔ **Objective**: Identify building characteristics have a noticeable impact on building energy consumption. Demonstrate how varying design parameters for each characteristic will impact annual energy consumption. The intent of this information is to provide the design team with information to make informed decisions on how to reduce the overall energy consumption of the building in line with the LCCA process.

➔ **Areas of Study:** Create energy models to understand annual building energy consumption by end use and peak heating and cooling loads with identical HVAC systems and internal occupancy and equipment-based loads. Perform a sensitivity analysis by varying the following building characteristics, as applicable, based on project considerations:

1. Window-to-wall ratio, by orientation, and shading options.
2. Orientation of the building.
3. Thermal performance of the envelope.
4. It should be noted that HVAC system type is not a primary consideration of this phase. The model shall utilize the applicable system type based on the ASHRAE Appendix G.

➔ **Final Deliverables:** Upon completion of this phase the energy modeler provides the following documentation to the Owner:

1. A completed LEED calculation spreadsheet is not required for this phase. Only the following information needs to be included in the spreadsheet:
    a. Energy sources and cost per unit energy (e.g., grid electricity, campus steam, campus chilled water, etc.).
    b. Outside air and exhaust airflow rates for each HVAC system.
    c. Energy Modeling Inputs and Schedules of Operation for the following:
        1) HVAC systems
        2) Service (i.e., domestic) water heating
        3) Interior lighting
        4) Receptacle equipment
        5) Exterior lighting (if applicable)

6) Process loads (if applicable)

2. A list of conceptual design options and the relative energy consumption and impact on energy utility infrastructure. This list is to be developed with the LCCA design options methodology outlined in the LCCA guidelines.

4.4 PHASE 2: SCHEMATIC DESIGN PHASE

- ➔ At the start of this phase the building footprint, programming, orientation, and envelopes shall be known or have a negligible risk of any major changes occurring as the design progresses.
- ➔ **Objective:** This phase consists of two parts, each having a distinct purpose as follows:
  1. Part I: Provide the design team and Owner with information to make informed decisions for the design elements that have an energy impact and that are planned or can be reasonably modified in the building.
  2. Part II: Once a consensus on the major systems has been reached, provide a complete energy model for the facility to assess the potential reduction in energy consumption.
- ➔ **Areas of Study:** During Part I of this phase the energy modeler shall assess the following:
  1. Mechanical Systems: Three HVAC system types shall be considered. The Owner shall review the options prior to analyses to determine they are appropriate for use.
  2. Ventilation: Airflow Reduction Strategies
  3. Lighting: Reduction of electric lighting power density and use of daylighting control systems. Consider high efficacy lighting and efficient ballasts. Focus on lighting control strategies for each space based on the energy model, such as occupancy and daylight sensors.
  4. Renewables: Consideration of renewable energy possibilities.
- ➔ **Final Deliverables:** Upon completion of each part of this phase the energy modeler shall provide the following documentation to the Owner:
  1. For Part 1:
     a. A report detailing the estimated energy consumption of each design option in line with the LCCA reporting requirements.
  2. For Part 2:
     a. A complete LEED calculation spreadsheet (as required by <u>Energy Modeling Requirements & Methodology</u>).
     b. Proposed Energy Consumption Spreadsheet.

4.5 PHASE 3: DESIGN DEVELOPMENT PHASE

- During this phase, the major elements of the design shall be set in place and the model created in the schematic design phase will be updated and refined.
- **Objective:** Provided data to finalize the selection and sizing of equipment and give a refined estimate on the energy efficiency of the design.
- **Areas of Study:** Throughout this phase the energy model will serve as a tool to make informed decisions about the following:
  1. Sizing ductwork and piping should result in a refined value for systems pressures and power requirements.
  2. Incorporation of refined data from the architect and Owner regarding receptacle equipment loads, occupancy schedules, space conditions, hours of operation, and process loads.
  3. Incorporation of refined values for lighting power density and lighting controls.
- **Final Deliverables:** Upon completion of this phase the energy modeler provides the following documentation to the Owner:
  1. A complete LEED calculation spreadsheet (as required by <u>Energy Modeling Requirements & Methodology</u>).
  2. Proposed Energy Consumption Spreadsheet.

4.6 PHASE 4: CONSTRUCTION DOCUMENTS PHASE

- On the outset of this phase any design decisions impacting energy consumption should be finalized based on the results of the design development phase's energy model.
- **Objective:** This phase will provide the best estimate of the building's operational energy efficiency based on the design documentation.
- **Areas of Study:** This energy model will incorporate all aspects of the design. Clear documentation of assumptions that cannot be determined until the building is constructed and operational, such as occupancy schedules, shall be clearly identified in the LEED calculation spreadsheet.
- **Final Deliverables:** Upon completion of this phase the energy modeler provides the following documentation to the Owner:
  1. A post-occupancy verification plan to provide real-world data to replace the assumptions made in the energy model. The plan must detail how the Owner can collect data once the building is occupied with references to specific drawings and energy meters used in the building.
  2. A complete LEED calculation spreadsheet (as required by <u>Energy Modeling Requirements & Methodology</u>).
  3. Proposed Energy Consumption Spreadsheet.

4.7 PHASE 5: POST OCCUPANCY VERIFICATION

- This phase shall occur after the Owner has obtained 12 months metered data post building occupancy.
- **Objective:** To provide a benchmark of peak energy performance for use in retro commissioning.
- **Areas of Study:** Document any notable differences either in the original energy modeling inputs (i.e., assumptions, schedules, set points, etc.) and the metered data provided. The energy modeler shall also document any noticeable difference between the original energy model results and the metered data.
- **Final Deliverables**: Upon completion of this phase the energy modeler provides the following documentation to the Owner:
  1. Post-occupancy review; A comparison of the updated energy modeling data with the metered data. Document any discrepancies and provide insight into the potential cause.
- **Post Verification Review:** A discrepancy of greater than 10% between model and metered energy results will trigger a post-verification review by UMass Chan of the energy model and commissioned equipment to determine the cause of the discrepancy. This review lies outside the scope of this document and is conducted at the discretion of UMass Chan.

ENERGY MODELING WORKFLOW CHECKLIST

Figure 9: Sample Energy Modeling Workflow Checklist

Phase	Deliverable	Initial Review		Revisions		Final Review		Comments
		Performed by	Date Complete	Performed by	Date Complete	Performed by	Date Complete	
0 - Planning	Energy modeling plan							
1 - Concept	LEED Calculator							
2 - Schematic	Design Options Report							
	LEED Calculator							
	Energy Consumption Spreadsheets							
3 - Detailed Design	LEED Calculator							
	Energy Consumption Spreadsheets							
4 - Construction	LEED Calculator							
	Energy Consumption Spreadsheets							
	Retro- commissioning plan							
5 - Post-occupancy	Post-occupancy Verification							

GLOSSARY OF TERMS AND ABBREVIATION

A. **Owner:** University of Massachusetts Chan Medical School
B. **ASHRAE Appendix G:** This refers to Appendix G in ASHRAE Standard 90.1, “Energy Standard for Buildings Except Low-Rise Residential Buildings.” The year of this standard will be as referenced by the applicable version of the International Energy Conservation Code (IECC) that will be enforced for the design of the project as mandated by Massachusetts State Building Code 780 CMR or the Authority Having Jurisdiction (AHJ).
C. **Building energy simulation:** Building energy estimation using a computer simulation program.
D. **Building performance rating system:** A program to assess energy and/or environmental performance of a building design.
E. **Comparative analysis:** A modeling exercise comparing the performance of two or more design alternatives in which the important result is the relative performance of alternatives.
F. **Compliance analysis:** A modeling exercise to demonstrate design compliance with energy standards or other program requirements.
G. **Construction document phase:** The final portion of the design process in which detailed plans and specifications are completed.
H. **Design development phase**: The stage in the design process where the initial schematic design is refined and detailed. This phase involves finalizing the design concept, selecting materials, and developing detailed plans for structural, mechanical, electrical, and plumbing systems.
I. **Energy end use**: A component of building energy consumption due to a specific application, including (but not limited to) lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC system equipment (such as pumps).
J. **Energy model**: A computer representation that provides information on the systems (e.g., HVAC, lighting, occupancy, plug loads, building envelope) that affect energy consumption in a building. The representation of the building serves, along with weather data, as the input data for a computer simulation program. When run, the program will simulate the energy use and demand in the described building for a time interval. Depending on the software program and how it is set up, various kinds of outputs may be produced.
K. **Energy modeler**: An individual with primary responsibility for the performance of the activities defined in these guidelines.
L. **Energy modeling**: The process of developing an energy model and running a building energy simulation.
M. **Energy sources**: Electricity, natural gas, fuel oil, propane, purchased heating, purchased cooling, and other building energy utility inputs.
N. **EUI**: Energy Utilization (or Use) Index is the measure of the total energy consumed in a building, expressed as energy per gross square foot of building area, typically kbtu/sf/yr.
O. **Process energy**: Energy consumed in support of a manufacturing, industrial, or commercial process other than conditioning spaces and maintaining comfort and amenities for the occupants of a building.
P. **Process load**: The load on a building resulting from the consumption or release of process energy.
Q. **Schematic design**: The early design phase in which fundamental elements of design, such as building form and HVAC system type, are typically determined.

R. **kBTU**: 1,000 BTU
S. **MMBTU**: 1,000,000 BTU
T. **Therm**: 100,000 BTU
U. **Ton Cooling:** 12,000 BTU/hr

END OF DOCUMENT