**Virtual Design for Energy technologies**
**Master Course Outline**

**Proposed Title**: Virtual Design for Energy Technologies (NRG 181)
**Credits: 5 credits**: (55 contact hours)
**Course Format**: In-Person Lecture-Lab / Online Content – Hybrid
**Grading Option**: Decimal grade

**Course Description:**
The objective of this 5 Credit course is to prepare students with foundational technical skills in the use of Building Information Modeling (BIM) for high performing/renewable energy systems in the built environment. Topics include whole building energy systems modeling for design, analysis, and detailing. The course focuses on Autodesk Revit MEP.

Prerequisite: Completion of NRG 102 or 162, and 180; or Instructor Permission.

**Course Rationale:**
Building information modeling (BIM) has become the industry standard practice for documenting and communicating design information quickly and effectively. Autodesk Revit is widely used by architects, designers and modelers as a primary BIM authoring tool. BIM data is used by analysis tools for energy, solar and lighting performance. The quality of BIM models for analysis is highly dependent on the content and completeness of design information in the model. This course will provide the necessary technical background and hands-on training to create BIM models that can be used for energy analysis and related building performance.

**Topics to be covered**:

- **Introduction to BIM** – Terminologies, concepts and introduction to Building Information Modeling and parametric modeling.
- **Create BIM Models** – Setting up MEP project using Revit to create BIM models using conceptual masses and building elements.
- **Define Spaces and Zones** – Introduce the concept of creating thermal zones from Revit spaces and rooms, and specify the zone data for heating and cooling loads analysis, and energy simulation
- **Model Views and Model Validation –** Learn to create views and schedules to review and validate the energy model geometry and thermal zoning
- **Heating and Cooling Loads Analysis –** Review BIM model data of geometry, internal loads and thermal zone properties and calculate heating and cooling loads using the legacy Revit loads calculation
- **Interoperability and Energy Simulation** – Introduce the workflow to export gbXML model data for energy analysis using EnergyPlus or OpenStudio
- **HVAC Networks –** Learn to add mechanical equipment, air terminals, ducts and pipes; introduce the duct sizing calculations

- **Solar and Lighting analysis –** Use the BIM model and cloud rendering techniques to perform solar and lighting analysis using Insight plugin in Revit.

**Skill to be Mastered** (objectives): (upon completion of this course students will…)

- Illustrate the basics of Building information Modeling
- Create and enhance BIM models of MEP systems in Revit models
- Demonstrate the basics of collecting and representing energy analysis requirements in BIM models including:
    - Thermal properties of envelope materials and components
    - Thermal zone properties (heating and cooling setpoints)
    - Space properties (occupancy, schedule and internal load properties)
- View and validate BIM models for heating and cooling loads analysis
- Export gbXML data for load and energy calculation using third party analysis software
- Perform solar and lighting analysis for determining PV potential and LEED compliance
- Prepare reports, charts and rendered BIM models for client presentations

**Outcomes to be measured** (Student's completing this course will be tested on their competencies to…)

- Create conceptual masses and building element models of buildings
- Demonstrate the collection and representation of data in BIM models for envelope materials thermal performance
- Identify the difference between rooms, spaces, thermal zones in a BIM model
- Generate an energy analytical model and calculate heating and cooling loads
- Export gbXML data containing all the information needed for exporting Revit geometry and energy model data
- Perform design options analysis for selecting envelope components, HVAC and lighting systems
- Demonstrate the design and detailing of HVAC systems, duct and piping layout for simple systems

**Prerequisites** (Prior Knowledge)**: (**Students entering this course should have the following experience and competencies.)

- Be competent in the following math skill:
    - Conversion between fractions, decimals and percentages.
    - Solving single variable algebraic equations.
    - Solve for sides and angles of a right triangle, Pythagoreans theorem and Trigonometry
- Understanding building science and energy calculations (including basics of heat transfer, thermal and indoor environment characteristics).
- Have completed NRG 102 and/or 162/163/200 prior to taking this course.
- Be able to operate a computer and use basic software for the development of documents.

**Assessment** (what you plan to asses and how)
Students will be required to prove competency in meeting each of the course objectives as listed above. The methods used to measure this competency will include:

- Weekly computer model creation exercise using project-based learning principles using campus buildings.
- A final project compiling all the weekly exercises into a portfolio of a complete MEP model with all the BIM data and results for energy, solar and lighting analysis.

**Course Outline** by Topic

Topic 0 – Course Introduction
Topic 1 – Fundamentals of BIM
Topic 2 – Setting up a MEP Project
Topic 3 – Modeling Building Elements, Envelope and Curtain Wall Systems
Topic 4 – Creating Analytical Spaces and Thermal Zones
Topic 5 – Heating and Cooling Loads Analysis
Topic 6 – Interoperability – gbXML Basics and Export
Topic 7 – Energy Analysis Workflows
Topic 8 – HVAC Systems, Duct Layouts and Piping
Topic 9 – Model Views and Cloud Rendering
Topic 10 – Lighting and Solar Analysis

**Course Materials and References:**

1. Introduction to BIM, Autodesk Design Academy, 2015 – Online course material available at: https://academy.autodesk.com/curriculum/introduction-bim

2. Whitbread, Simon. 2016. Mastering Autodesk Revit MEP 2016, Autodesk Official Press, Wiley and Sons, Indianapolis, IN.

3. MEP Modeling, Autodesk Knowledge Network Learn and Explore web content available at: https://knowledge.autodesk.com/support/revit-products/learn-explore/caas/CloudHelp/cloudhelp/2018/ENU/Revit-Model/files/GUID-195C2C6C-5E2C-422E-A44D-FB3FDFDE276A-htm.html?v=2018

**Computer:**
Students will be required to have access to a computer and be able to connect to the Internet. Further they will be required to navigate the classes the learning management system (Canvas) to view presentations and complete course work and quizzes.