A rather surprising result is only at very high occupancy levels did the model start to show an effect from occupancy changes. The limitation of modeling actual human behavior is evident here as the occupancy schedule would almost never be fixed in such a building which would really be the case with most buildings.

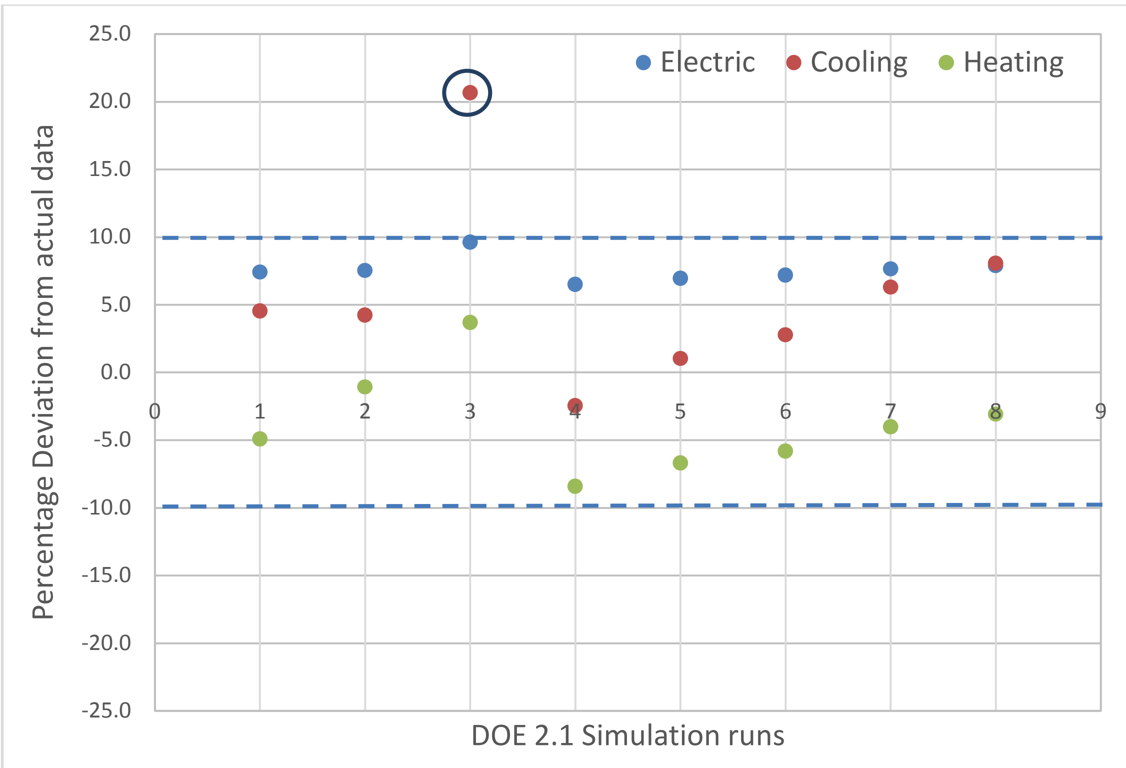

Figure 14. Percent Deviation from Actual Building Energy Consumption Data for Differing DOE-2 Models.

A primary driver for this study was to determine if there were significant deviations in the energy model for a building if the actual occupancy level and/or occupancy schedule were not known. It appears, for the case of this particular university building, that only at an extreme loading (occupancy) level would one expect to see impacts on the annual energy consumption. This is a reassuring result for a designer/energy modeler when performing parametric analysis on a new or existing building. It is shown in this study, that even if the hourly or daily energy profile might not be accurately modeled, that the annual energy consumption will be relatively insensitive (within ±10%) to occupancy errors of up to ±50%.

7. CONCLUSIONS

The research provided a better understanding of the sensitivity of building energy simulation tool with occupancy in a typical university classroom building. The results of this research should be of interest to architectural/engineering designers and facility managers involved in the design/construction and operation of an institutional facility. It was observed that the energy simulation tool (DOE-2) was able to generate an energy model to within ±10% of the actual annual energy consumption data if original occupancy was entered into the model. Even if a designer assumed constant occupancy schedules instead of variable schedules, very little deviation in the annual energy model was observed. Facility managers can depend on the model results if actual occupancy is entered and could use it as a tool to forecast annual energy expenditures for these type buildings and not have to be concerned with high accuracy in occupancy numbers. The results of this work clearly showed that total occupancy or occupancy schedules do not have a significant impact on annual energy use in a university classroom building. As noted earlier, this particular building does not have occupancy sensors on the lighting systems and there are no occupant adjustable thermostats. The lighting systems were observed several times during the study period (Fall and Spring semesters) and lighting was found to be on almost 100% of the time. This building is also not yet converted completely to a direct digital control system for the HVAC equipment and thus, this equipment runs 24 hours, 7 days per week. Even when zero occupancy was modeled, simulated result are still within the range of ±10% deviation on annual energy use which shows that there is very little impact of occupancy in this institutional classroom building. As found in the literature review, there is basically no way to model actual human occupant behavior in any type of building. It is possible to model the *results* of behavior; leaving lights on, opening windows, blocking doors open, etc., but these behaviors are not known a priori. Designers, especially, do not have that type of information at hand during the design phase of a building.

The research provides confidence to designers in their energy modeling work. Even if they model a building using an occupancy with a schedule that is 50% higher or lower than what the actual building will support, their error on annual energy performance will not be greater than ±10%. These results may not be within same confidence level when extended to different kinds of buildings and occupancy. Future work should include extending similar research to different categories of buildings with different types of occupancy and hence differing occupant behavior.

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