IQ3

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INTEGRATED ENVIRONMENTAL SOLUTIONS

< Virtual Environment >

BIM AND PERFORMANCE ANALYSIS

INTRODUCTION

The 3rd edition of the IES – US Sustainable Impact Quantification (I.Q.) focuses on BIM+Performance Analysis, specifically an example of a workflow for early stage analysis informing design decisions. Project teams are just beginning to grapple with the issue of how energy modeling can impact the process. The tendency is to push the development of the energy models later in the process where more detail is understood and it only has to be done once. However, to really influence the design at early stages, performance analysis snapshots (simplified versions of energy modeling) need to be developed. This Sustainable I.Q. provides one example of a number of Performance Analysis Workflows that a project team can incorporate into their process now, so be creative and shape your own!

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SCENARIO:

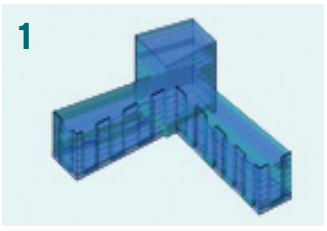
An architect is investigating the performance differences of three building forms for an office building (200,000 s.f.). This scenario covers developing massing, shaping the initial BIMs, the initial simulations, and beginning to "dive into" the results to direct the next moves. It serves as a higher level discussion weaving some of the different threads of the IES VE-Toolkit analyses together, to act as a portal to additional information and results.

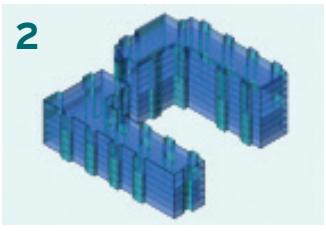
The meeting earlier in the week for the 200,000 s.f. office building with the client was the first that started to explore form, orientation and how the program could be shaped to meet their needs. The analysis the team presented on the sustainable strategies the climate and habitat presented as feasible opportunities served as a very good lead to kick start the discussion.

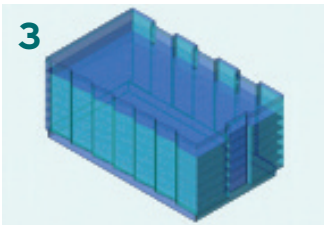
The result of the discussion was the identification of three different building schemes that now need to be put in the 'feasibility filter' to quantify performance and alignment with the teams' goals (environmental and financial). The BIM + Performance Analysis models need to be developed and initially analyzed, so that they can be dynamically adjusted during the next meeting to provide real-time feedback to the follow-up questions that always seem to come up.

The three schemes provide very different forms, so it will be interesting to see how they will stack up to each other and the other project metrics that were agreed upon. The process of setting up the models should not take much effort because the group agreed that at this early stage only the form and envelope ideas should be incorporated.

By agreeing on the boundary conditions for the analysis the team will be able to shape the analysis in a quicker timeframe and will also be able to perform additional simulation runs to begin to identify the sensitivity of different efficiency measures and assess if they should be pursued further. Since the building forms are the main focus of the comparison, and the building envelope has only started to be designed, the performance analysis snapshot will focus on building energy. The three models are being developed in Google SketchUp™ and Revit to develop the mass and volumes and the Google SketchUp, IES/Revit link and IES VE-Toolkits will be used to calculate peak building loads and shape the full year energy picture and carbon footprint.







The three forms depicted above were created for an owner for an office building that is approximately 200,000 ft2 (18,600 m²). They serve as the basis of the comparative analyses depicted within this tutorial.

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....the next morning – the designer has done a very good job shaping the three BIM models, developing the initial analysis, and laying out the picture of the current results. The emphasis of the group will be to dig into the results and shape a presentation that focuses on the "quality" versus "quantity" of the information. The initial results[6] were fairly surprising and differ from what was anticipated. The analysis was done to answer three initial questions:

QUESTION 1: WHAT AFFECT DOES THE FORM HAVE ON ENERGY CONSUMPTION IF THE SYSTEM TYPE IS CONSISTENT?

To address this question the three models were run with a split system with mechanical ventilation and cooling. The table shows that the "rectangular form" is the current best performer based on the total energy consumption for the year being 53.6 kbtu/sf/yr[5]. The worst of the three forms is the wing shape, which is 11% higher, while the U-shape is 6% higher. This result differs from what was anticipated and raises questions, such as what is the percentage glazing and wall surface area for each form. It turns out that the "wing shape" has the highest percentage glazing at 62%, while the "rectangular form" is second at 57%. This may not seem like much of a difference until the overall wall surface area is considered, where the "rectangular form" has only 50% of the vertical surface area that the "wing form" does[8]. Therefore the 5% glazing difference equates to 47,000 sf additional glazing for the "wing form", and leads to a substantially higher cooling peak load for the building.

	Description	System Type	Size	Energy Consumption (yearly)	
			s.f.	MMbtu	kbtu/sf/yr
1	Wing	split system w/mech vent-cooling	198,175	11,752	59.3
2	U-shape	split system w/mech vent-cooling	215,374	12,272	57.0
3	Rectangular	split system w/mech vent-cooling	203,572	10,910	53.6

TABLE 1.1 - FORM COMPARISON 1 - SIMILAR SYSTEM TYPES

QUESTION 2: WHAT DIFFERENCES DOES A SYSTEM TYPE CHANGE (SPLIT SYSTEM VERSUS VAV DUAL DUCT) PRESENT FOR EACH FORM?

To assess the impact of different systems on the three forms, simulation runs for a VAV Dual Duct system were run for each. In each case the "VAV Dual Duct" system was the better performer. The largest impact was a 5.5% reduction for the "rectangular form", while the lowest was a 3.7% reduction on the "wing form".

Looking at the different assumptions for the two system types[7] for the VAV Dual Duct system the efficiency for both the boiler and chiller are better, which begins to explain the lower MMbtu values. Also the "rectangular form" based on its floor plate relies more (increased usage) on the HVAC system, so the increased system efficiencies have a greater impact.

	Description	System Type	Size	Energy Consumption (yearly)	
			s.f.	MMbtu	kbtu/sf/yr
1	Wing	split system w/mech vent-cooling	198,175	11,752	59.3
		vav dual duct	198,175	11,314	57.1
2	U-shape	split system w/mech vent-cooling	215,374	12,272	57.0
		vav dual duct	215,374	11,750	54.6
3	Rectangular	split system w/mech vent-cooling	203,572	10,910	53.6
		vav dual duct	203,572	10,306	50.6

TABLE 1.2 - FORM COMPARISON 2 - VARYING SYSTEM TYPE

QUESTION 3: WHAT IS THE POTENTIAL OVERALL IMPACT ON ENERGY CONSUMPTION OF INCORPORATING A NATURAL VENTILATION SYSTEM?

We've now investigated some of the standard office building system types, so what if a passive or hybrid system such as natural ventilation or mixed mode ventilation was introduced? What impact would it have in the context of this analysis? The "wing and U-shape" forms are the best candidates, and the results for the "wing form" are shown below.

If a "split system with natural ventilation" was incorporated it could reduce the yearly energy consumption by up to 35% as compared to the "split system", and lower the kbtu/sf/yr to 38.8, which would be a substantial achievement for an office building, if it could be realized and maintained through the process.

	Description	System Type	Size	Energy Consumption (yearly)	
			s.f.	MMbtu	kbtu/sf/yr
1	Wing	split system w/mech vent-cooling	198,175	11,752	59.3
		vav dual duct	198,175	11,314	57.1
		split system w/ natural ventilation	198,175	7,681	38.8

TABLE 1.3 – FORM COMPARISON 3 – EXPANDING SYSTEM COMPARISONS

WHAT HAVE WE LEARNED SO FAR?

A substantial amount of information has been brought to the table for the team to consider, and some of the key takeaways are:

- Useful boundaries for energy efficiency impacts have been indentified which will inform what potential $ savings are on the table.
- Even for a high performance envelope natural/mixed mode ventilation can play a major role in reducing energy consumption.
- Additional parameters such as daylighting and thermal comfort (which can be explored with IES VE-Toolkits) should be brought into the picture so that the best performer from this analysis, the "rectangular form", can have feasibility assessed in other ways.

PRIOR TO THE NEXT MEETING

The designer has been asked to run a short list of additional simulations including – reducing glazing by 10%, changing wall insulation levels to even higher performance levels, changing glazing types on the north side and incorporating shading devices on the south and west side to give feedback on some of the ideas that had been previously mentioned and should kick start other interesting thoughts. It will be interesting to see what the added parameter of performance analysis will have on the direction and tone of the discussion. And it will be interesting to see how providing quantifiable feedback within the context of the meeting with the BIM + performance analysis flow will inform decision making and hopefully change the dynamic from the "trust me, we did this on the last project" that has been part of so many past meetings to "analyzed data". The mindset of a number of folks will need to expand for this to begin to be successful.

CHALLENGES: WHAT DECIMAL POINT PRECISION DO YOU THINK YOU NEED?

One of the challenges of effectively weaving analysis into earlier stages in the process is reaching agreement (or at least understanding) among the project team and owner of what degree of detail can be expected from the analysis. The concept of "fuzzy numbers" (a good kind of fuzzy), is something numerous teams struggle with, and it can end up closing doors if the owner or engineer is not careful. The owner needs to be comfortable that the results from early stage analysis will have a significant tolerance (+/-) to them and are focused on comparative analysis. The engineer needs to be comfortable that if they say 27% efficiency that the owner won't use that number to haunt them in the future, if the value goes down. Without a mutual comfort level and understanding, the analysis just becomes an exercise and not one that is informative.

FIND OUT HOW TO FURTHER INTERPRET, SHAPE AND PRESENT ANALYSIS RESULTS IN IQ4

I.Q. TIP: PROCESS WORKFLOW FOR PERFORMANCE ANALYSIS

The following is a summary of the "workflow" described in the scenario and that is presented in greater step by step detail in the IES Tutorial: Comparative Analysis – Version 1 - Building Form[1]
http://www.iesve.com/downloads/ies_tutorial_comparative_analysis_v3.zip

1) DEVELOP BIM – MASSING & VOLUMES
- a. Create massing using tools
- b. Identify floors/levels
- c. Apply boundaries (floors, wall types, glazing, etc)
- d. Input room tags and set correct upper limits and offsets[2]

2) INPUT/CONFIRM PERFORMANCE ANALYSIS DATA
- a. Check geometry and model data
- b. Input/Confirm building data (max.13 inputs)
  - i. Type, construction, system and location

3) IES <VE> TOOLKITS – PERFORMANCE ANALYSIS

Note: Toolkits = Five options for analysis. This tutorial investigates the ApacheSim: Dynamic Thermal Simulation.
- a. ApacheSim = Full Year Energy Consumption
  - i. Press the button and watch the action!
- b. Save ApacheSim output .html report that quantifies (5) types of result metrics.
- c. Run & Save ApacheSim results for the other two building forms

4) INTERPRET THE RESULTS
- a. Review the output and identify the relevant numbers for comparisons (ex. MMBtu values)
- b. Shape the Architecture 2030 target using either TargetFinder or the table provided by Architecture 2030 (dependent on building type)[3,4]
- c. Collate the relevant numbers for each building form
- d. Post process the results if needed to compare to Architecture 2030 target (refer to tutorial)
- e. Shape a top 5 or top 10 observations from the results

5) SHAPE NEXT STEPS
- a. Use the list of observations to identify:
  - i. Is the team comfortable with the results?
  - ii. What needs further explanation?
  - iii. What other information needs to be established for the different building forms?
  - iv. What other types of analysis are needed?
  - v. What are the top 3 critical questions?

Reference Sources:

1) IES VE-Toolkit Tutorial: Comparative Analysis Version 1 - Building Form
http://www.iesve.com/downloads/ies_tutorial_comparative_analysis_v3.zip

2) IES/Revit Model Guidance
http://www.iesve.com/content/default.asp?page=s97_1

3) Energy Star Target Finder -
http://www.energystar.gov/index.cfm?fuseaction=target_finder.

4) 2030 Targets Table -
http://www.architecture2030.org/2030_challenge/targets.html

5) Environmental Building News – Dec 2007 Back-page primer - Energy Metrics: Btus, Watts, and Kilowatt-Hours -
http://www.buildinggreen.com/auth/article.cfm?fileName=161220a.xml

6) Building-Form Comparison-Results Matrix
http://www.iesve.com/content/mediaassets/pdf/Bldg-Form Comparison-Results Matrix.pdf

7) Building-Form System Type Assumptions Table
http://www.iesve.com/content/mediaassets/pdf/Bldg-Form System Type Assumptions Table.pdf

8) Building-Form Comparison-Additional Info
http://www.iesve.com/content/mediaassets/pdf/Bldg-Form Comparison-Addtl Info.pdf

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