Improving Building Energy Modeling and Analysis Processes using the graph database Neo4J

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OBJECTIVE

To evaluate if graph databases are suitable to run queries that detect differences between building models and examine the impacts of these differences on energy consumption.

INTRODUCTION

- Maximizing building efficiency is key in preventing climate change.
- Buildings account for 40% of primary energy consumption [1].
- Building Energy Modeling (BEM) programs take in building details such as geometry, construction materials, HVAC, etc and then combine this with weather information to calculate energy usage.
- BEM softwares like EnergyPlus are used to design energy efficient buildings [2].
- BEM softwares are time-consuming due to the many inputs required by the system. Their outputs are also overwhelming to navigate [3]
- Can EnergyPlus be used in combination with the graph database Neo4J to improve the analysis and simulation process of BEM softwares?

METHODS

EnergyPlus:

- 3 models of a detached-style home using EP-Launch were created.
- The starting model was taken from the Building Energy Informatics Lab [4].
- R-values and Ground Temperature were changed.
- A simulation was run on each of these models using Dublin weather data [5].

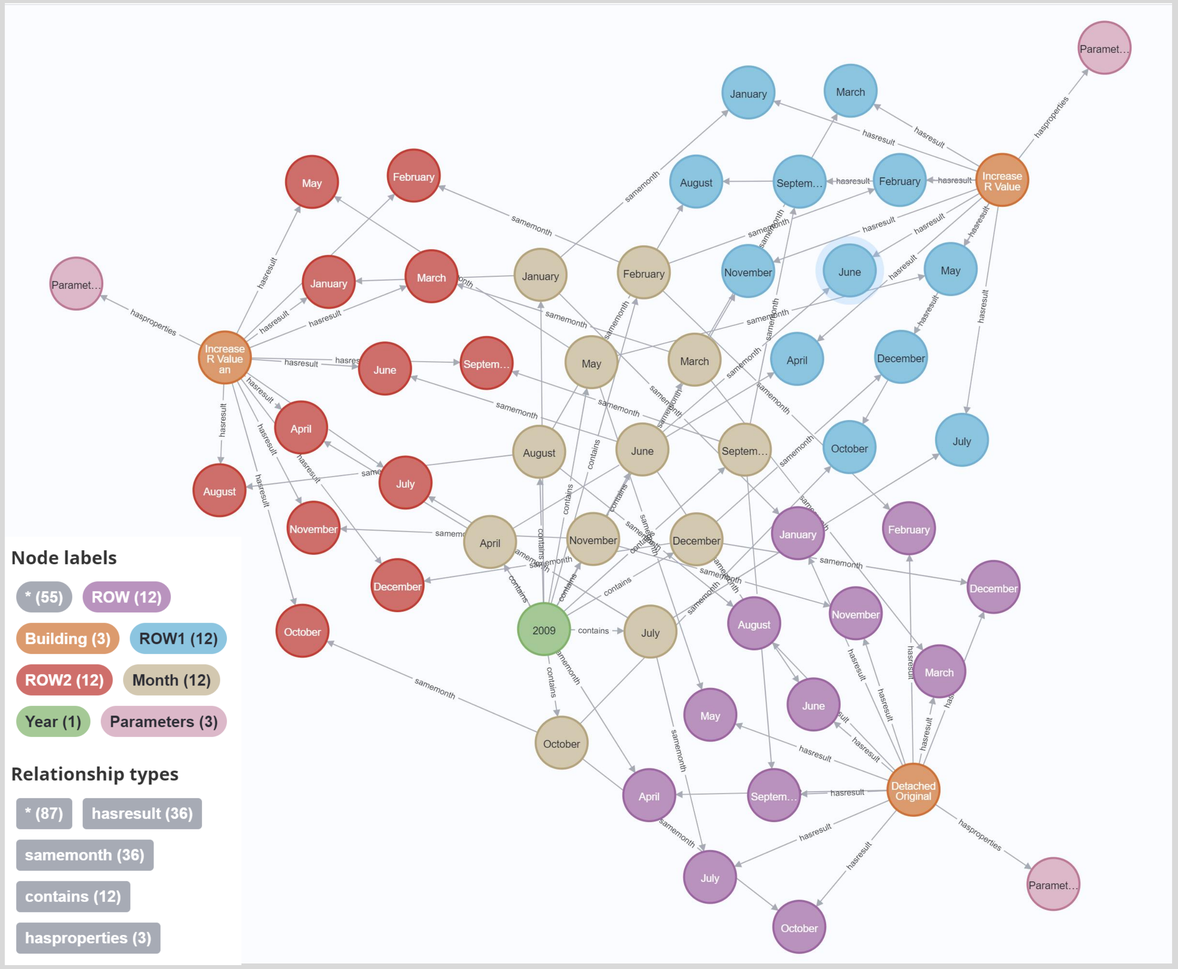
Table 1: Building Model Properties

Building Model	R Value (Thermal Resistance) (m^2 K /W)	Ground Temperature (C)
1 – Detached Original	0.6267, 0.15, 0.18	18
2 – Increase Wall R Value	0.75, 0.2, 0.22	18
3 – Increase R Value and Ground Temperature	0.75, 0.2, 0.22	20

Neo4J:

- Results were exported as CSV files.
- Building files were exported in epJSON form.
- CSV files were imported into Neo4J.
- Relationships between the output and building models were manually added.

RESULTS



Neo4J Graph of Connections between Building Models and Simulation Outputs

- Buildings models were connected to their corresponding EnergyPlus results via month nodes.
- The epJSON data was not uploaded into the graph.
- Building properties were manually added to "Parameter" nodes.
- Relationships between the same months were added.

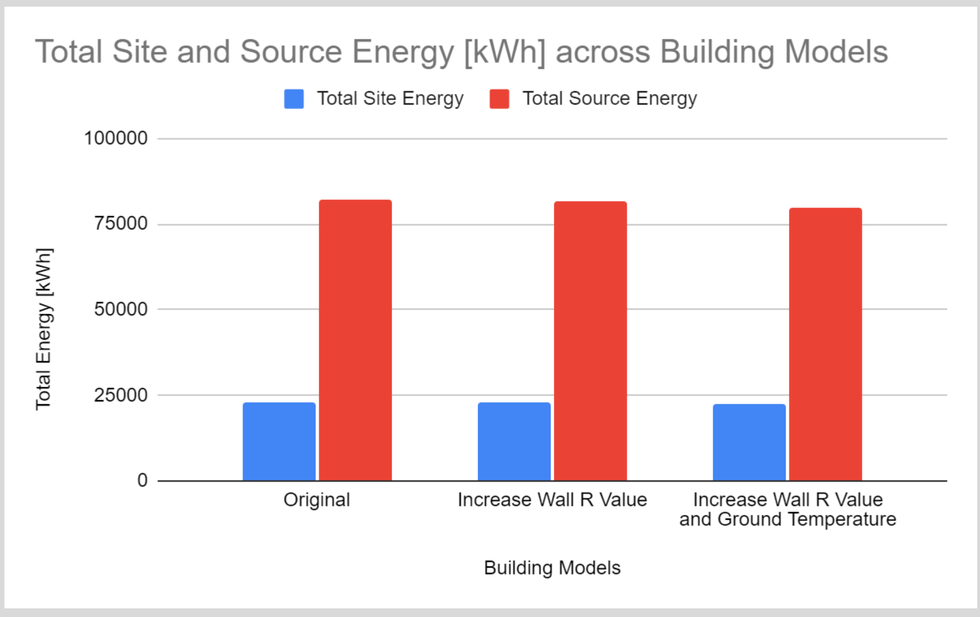
- When using this graph database, the user would not be looking at the graph but rather querying within it. The graph acts as visual representation of the connections within the data.
- A query was run to pull the Dry Bulb Site Temperature for January.

```
Match (month {name:"January"}) -[:samemonth]→ (buildingdata)

Return  buildingdata.drybulb
```

	buildingdata.drybulb
1	"5.7805779569892435"
2	"5.780577957"
3	"5.7805779569892435"

Sample Query



Building Energy Consumption [kWh] across Models

DISCUSSION

In this project, the graph database can be used to pull data from the same month and category across different building models. Creating more relationships can allow for more queries which allows the Neo4J approach to be expanded to many questions. One question left to explore is seeing if the graph can identify differences within the models and link these to differences in results. More work should be done to determine the best way to import the epJSON data.

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References:

[1] Egan, J., Finn, D., Deogene Soares, P.H., Rocha Baumann, V.A., Aghamolaei, R., Beagon, P., Neu, O., Pallonetto, F., O'Donnell, J., 2018. Definition of a useful minimal-set of accurately-specified input data for Building Energy Performance Simulation. Energy and Buildings 165, 172–183. https://doi.org/10.1016/j.enbuild.2018.01.012 [2] "About Building Energy Modeling." Energy.Gov, Office of Energy Efficiency and Renewable Energy, www.energy.gov/eere/buildings/about-building-energy-modeling. Accessed 14 Mar. 2024. [3] Corry, Edward. "A Semantic Web Approach to Enable the Holistic Environmental and Energy Management of Buildings." *University of Galway Research Repository*, University of Galway, 30 Oct. 2014, aran.library.nuigalway.ie/handle/10379/4810. [4] "The Building Energy Informatics Laboratory." *The Building Energy Informatics Lab*, University College Dublin, www.ucd.ie/buildingenergyinformatics/. Accessed 23 Apr. 2024. [5] "Weather Data Download - Dublin 039690 (IWEC)." *EnergyPlus*, https://energyplus.net/weather-location/europe_wmo_region_6/IRL/IRL_Dublin.039690_IWEC. Accessed 12 Feb. 2024.