SYNOPSIS

KEY POINT SUMMARY

OBJECTIVES

To show that design solutions that reduce the impact of regional climate conditions on facility energy usage will ultimately provide long-term fiscal and environmental benefits.

Energy analysis and forecast of a major modern hospital

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Key Concepts/Context

Globally, roughly 4.4% of all carbon dioxide (CO_2) emissions come from the health sector. In some countries, the public health sector may regularly be the leading energy user and emitter. There is diverging evidence to suggest whether regional climate patterns or building occupancy have a greater impact on energy use within healthcare facilities. This study suggests that improving the thermal performance of building envelopes and increasing space cooling efficiency may have long-term benefits.

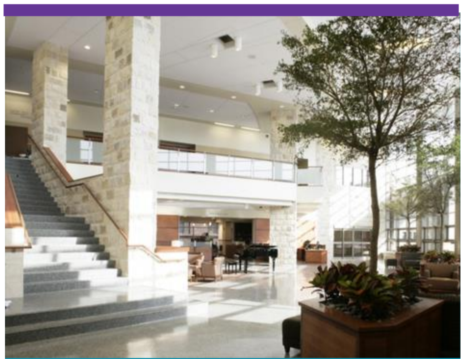
Methods

This study applies a range of data analysis methods to a large (three buildings, total floor area of 134,800 m_2) modern hospital located within a subtropical climate area (Brisbane, Queensland, Australia).

First, data were acquired concerning the hospital site, including building design information, climate data, occupancy data, and electricity data. Electricity and occupancy data were gathered in monthly increments. Monthly climate data were obtained from a governmental bureau of meteorology.

Following data acquisition, the data were analyzed using a correlation study, a principal component analysis (PCA), and regressions. The correlation study focused on the relationship between monthly electricity data, regional temperature data, and occupancy data. This involved the use of the Pearson correlation coefficient (PCC), the PCA, and regression.

Lastly, the study's extrapolation phase included building energy modelling and a series of forecasts predicting energy usage scenarios into the years 2030, 2050, 2070, and 2090. Projections for future weather were available through Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO). The authors recalculated the CSIRO data into monthly inputs, which were inserted into



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models derived from the data analysis phase. Several assumptions were involved in these projections, including:

- No significant building expansion
- Facility assets which go out of service are replaced with identical assets.
- Increased energy use from new clinical technology is offset by energy efficiency enhancements from other assets.
- Indoor thermal comfort is maintained throughout the period of 2030 to 2090.

Findings

An initial case study revealed that the study site's HVAC system accounted for the largest share of onsite electricity use. Natural gas was also used onsite for water heating and steam; however, the authors nominated to study these energy expenditures in future research. Initial data analysis from this case study indicated that onsite energy usage was related to ambient temperature; electricity usage was higher on average in the summer months (December to March in Australia), averaging between 75 megawatt-hours per day (mWh/day) and 87 mWh/day. Winter months (June to August) ranged from 65 mWh/day to 68 mWh/day.

Analysis of PCC values found that no variables related to building occupancy correlated with onsite monthly energy use. Similarly, there also appeared to be no relationship between occupied bed days (OBDs) and monthly electricity use. The fact that there is a low correlation between occupancy and electricity use but a high correlation with outdoor temperature suggests that hospital designers should focus on improving the thermal efficiency of building envelopes, thereby reducing growth in the HVAC system's cooling load.

Future projections found that annual electricity bills could increase by over 2 million Australian dollars (AUD) in a business-as-usual scenario. However, in a negative emissions scenario, this cost increase is significantly diminished, thus indicating that future technological improvements could help drastically mitigate costs.

Limitations

The authors note that their projections for future weather conditions were based on typical meteorological future climate files, meaning the projections assume that the weather would follow typical patterns within the 20-year increments, thus leaving out atypical weather events such as extended heatwaves. The other aforementioned assumptions (see Methods section) which helped the authors forecast future energy use scenarios may also be highly site-specific; designers considering using this data-driven approach to energy modeling might consider evaluating and altering some of these assumptions for their own site-specific needs.

Design Implications

This study suggests that improving the thermal efficiency of building envelopes could be the most effective way to offset growing energy costs while potentially moving towards negative emissions goals. Improving the staging and control of cooling-related equipment could also contribute towards improved sustainability.