

Modeling and design of tuned mass dampers using sliding variable friction pendulum bearings

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# PROCEEDINGS

## BOOK OF ABSTRACTS

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## Quantitative Assessment of Energy Consumption at the Urban Scale: the Ecological Footprint of a University Campus

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### Abstract

This paper explores the consumption-based ecological footprint method and its application aiming at performing a quantitative assessment of the sustainability of a university campus. The goal is to inform the planning decision-making process and evaluate the socio-technical solutions implemented in local urban settings to reduce energy consumption, decrease environmental impacts and improve the quality of life of the campus inhabitants. The case study taken for the analysis is the Politecnico di Torino, a 33,000-student-Higher-Education Institution (HEI) located in the north of Italy. Data were collected from different departments and administrative units of the Politecnico di Torino to estimate emissions and identify the pressure exerted by the campus activities on the local ecosystem during a reference year (2016). Six main categories of consumption were identified and associated with their ecological footprint, i.e., the amount of land needed to produce the required resources and to absorb the generated waste, including CO<sub>2</sub> emissions. Total footprint resulted in being of 6,200 gha: about the half of the total city area, meaning that the campus would need a 310 times larger area to be self-sufficient. Transports had the highest share, with 49.4% out of the total campus impact, whereas energy covered 40.1%. Food, waste, land use and water counted respectively for 5.7%, 3.7%, 0.7%, and 0.5%. This study presents the most comprehensive analysis to date of the environmental impact associated with an Italian HEI. This methodology and its development for the specific case of HEIs contributes to gain a better understanding of the overall impact of a university campus, as well as to create thresholds for comparative analysis, decision-making tools, and policy-making to reduce the carbon footprint of the educational sector.

**Keywords:** Emission analysis, Higher education, Sustainability assessment, Decision making, Carbon footprint.

## Enhancing the Accountability and Comparability of Different Campuses' Energy Profiles Through an Energy Clusters Approach

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### Abstract

Living lab facilities are increasingly supporting university campuses sustainability management by providing consumption patterns and performance indicators. Ranking systems set criteria to universities sustainability managers in order to motivate sustainability operationalization. However, current campuses' sustainability assessment tools do not provide specific consumption thresholds according to the different functions that could be hosted, or the building typologies or the geographic context. Because of this, the paper proposes the framing of different energy clusters, related to homogeneous consumption rates, enabling a meaningful comparison among campuses within the international rankings. Energy consumption profiles of two university campuses similar for climate, surface and population have been collected in a span of four years' time both at the Politecnico di Torino (Italy) and Hokkaido University (Japan). A partial regression analysis on these data revealed five different clusters of homogeneous consumption ranges: cluster 1 (around 1 GJ/m<sup>2</sup>/year) includes the Art departments, cluster 2 (around 2 GJ/m<sup>2</sup>/year) includes the Science faculties, cluster 3 (around 3 GJ/m<sup>2</sup>/year) includes the hospital and the medicine departments. Cluster 4 includes the Data Centre (around 9 GJ/m<sup>2</sup>/year), and cluster 5 includes special research facilities with consumption over 10 GJ/m<sup>2</sup>/year. The proposed energy clusters approach can significantly enhance the accountability and comparability of different and complex campuses' energy profiles, contributing to a better evaluation of universities' energy performances.

**Keywords:** Energy management, Assessment and reporting, Campus operation, Higher education, Sustainability.



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