

Thesis title: *Landscape to Digital Twins: A Geospatial framework for the Development of Energy Digital Twins (EDTs) for sustainable Urban Built Environment*

Abstract of the research:

Over the last decade, recent advances in geospatial technologies have enabled more detailed modelling of urban built environments through Urban Digital Twins (UDTs). Urban Digital Twins (UDTs) are dynamic data-driven digital representations of urban environments that integrate spatial, temporal, and semantic information to support analysis, simulation, and decision-making processes. This research focuses on Energy Digital Twins (EDTs), a specialized application of UDTs that simulates energy behaviour to improve urban energy efficiency. EDTs combine 3D city models from geospatial datasets to dynamically update energy metrics within the built environment. By integrating data from advanced geospatial techniques with energy metrics into 3D WebGIS platforms, this work presents a conceptual framework for the development of EDTs from the geospatial datasets. This framework provides a practical, operational, data-driven approach to urban energy planning and supports sustainable city development.

This doctoral research centres on the continuous efforts to establish a conceptual framework for developing an Energy Digital Twin (EDT) for the urban environments employing geospatial datasets to extract actionable insights for the smart energy management systems. This research develops operational procedures for energy modeling within Energy Digital Twins (EDTs), specifically the extraction of window and rooftop attributes from point cloud datasets. To address the practical challenges of building urban EDTs, the study evaluates computer vision methods for building feature extraction and analyses how dataset resolution impacts both accuracy of the building features extraction from the geospatial dataset.

The primary scientific contribution of this research is a comprehensive workflow for developing an Energy Digital Twin (EDT) from geospatial datasets. The methodology investigates the essential architectural elements required for EDT development and how they can be extracted from the geospatial datasets to construct the foundational 3D energy model. This research integrates geometric reconstruction, computer vision, and energy simulation into a framework for urban-scale energy analysis. The study evaluates how data resolution and feature sensitivity impact model reliability, establishing a technical foundation for the development of Energy Digital Twin (EDT) systems. This research provides the cities with a functional framework to visualize current energy scenarios and evaluate the impact of future urban developments. While commercial solutions exist, they often remain inaccessible to local governance; this work bridges that gap for developing a user-friendly platform specifically tailored for municipal decision-making. By streamlining the integration of 3D geometry and energy metrics, the study offers a practical, data-driven framework for authorities to implement and monitor urban sustainability policies.

Keywords: Urban Digital Twins (UDTs), Energy Digital Twins (EDTs), photogrammetry, point clouds, smart energy system, urban environments, feature extraction, energy modelling, solar energy, sustainability.