

GraphRAG-Based Product Selection: Multi-Criteria Sustainability in Construction

Multi-criteria decision-making for product selection in construction is becoming increasingly important, as purely technical and economic evaluations can no longer capture the complex demands of sustainability. In particular, ecological and socio-cultural criteria exert a decisive influence on the life-cycle assessment (LCA) of building materials and are embedded in certification systems such as DGNB and LEED, as well as in the EU Taxonomy and various ecolabels. Against this backdrop, an ontology-based decision-support system leveraging GraphRAG is under development. It systematically extracts relevant information from unstructured sources—technical data sheets, safety data sheets, and Environmental Product Declarations (EPDs)—represents this information within a knowledge graph, and makes it interactively queryable in combination with large language models (LLMs).

By integrating semantic ontology with AI-driven language processing, GraphRAG enables automated responses to complex, multi-hop queries: planners, contractors, and sustainability auditors receive context-aware recommendations that interlink technical performance, cost efficiency, and both ecological and socio-cultural dimensions. For example, the system can identify low-emission insulation materials that not only satisfy energy-performance requirements but are also manufactured under socially responsible production conditions. To validate the system, structured expert interviews were conducted with stakeholders from architecture, site management, and certification bodies. These interviews captured typical information needs and decision workflows, from which a set of “must-have” queries was derived—queries that GraphRAG must answer reliably and transparently. Particular emphasis was placed on performance under multi-query scenarios, such as the concurrent evaluation of life-cycle costs, carbon dioxide (CO₂) equivalents, and health-relevant emissions.

Evaluation results demonstrate that GraphRAG provides significant time savings and enhanced transparency in the decision-making process compared with conventional research methods. In the long term, this approach promises to systematically promote more sustainable construction products and to streamline the practices of product selection and certification.

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Track Classification: Materials Flow: Life-Cycle Analysis