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Integrated BIM Framework for Minimizing Embodied Energy in Heritage Buildings: A Study in Old Downtown Amman with Darat al Funun Building

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INTRODUCTION & AIM

Careful material selection is paramount in sustainable construction

- Considering operational and embodied energy (EE) throughout a product's lifecycle
- EE is critical in heritage structures, reaching up to 30%.
- Operational energy typically dominates conventional buildings' energy use.
  - Scrutinizing energy consumption across a building material's lifecycle is vital, influenced by several factors:
    - Manufacturing
    - Transportation
    - Installation

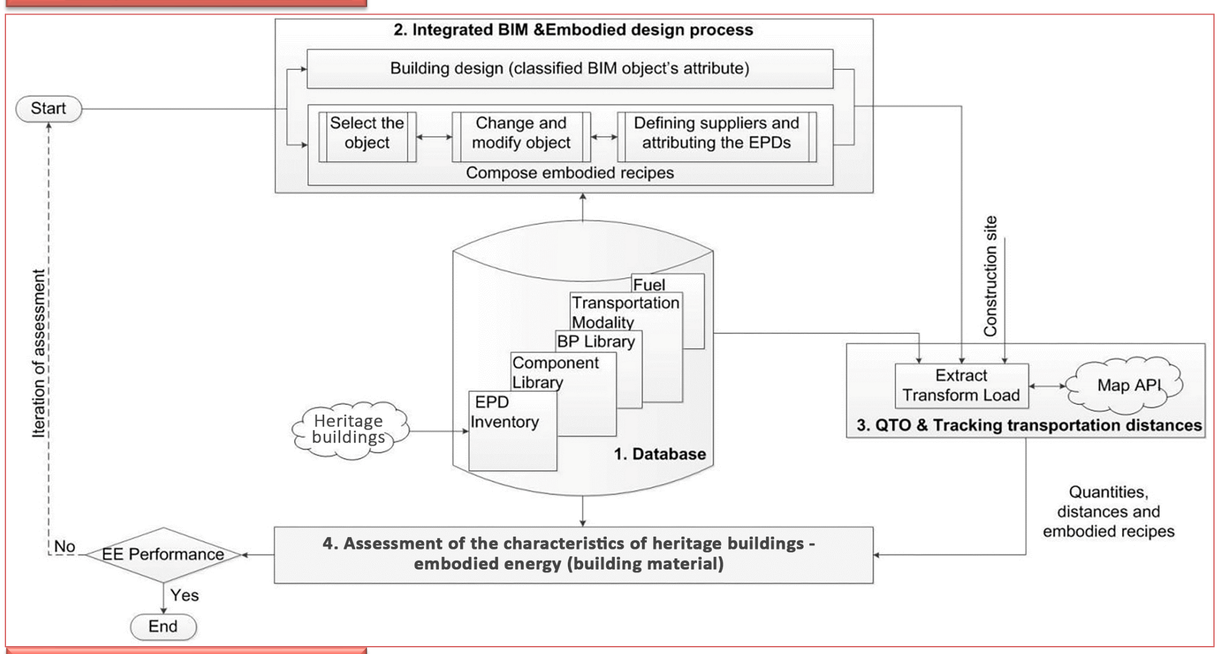
The research aims to comprehensively assess the embodied energy of heritage building materials in Jordan:

- It aims to explore ETL technologies for enhancing BIM-LCA interoperability.
- Informing sustainable building practices in Old Downtown Amman using Darat al Funun as a case study.
  - To address the literature gap on integrating embodied energy assessment in heritage environments within BIM processes.

METHOD

- This study employs two main components: a suggested framework and a created prototype.
- The suggested framework delineates conceptual differences, necessary procedures, and information exchange for evaluating the embodied energy linked to the supply chain of building materials.
- Meanwhile, the developed prototype applies the framework and acts as a tool to assess its feasibility in the case study. As shown in the Chart 1.

❑ Proposed framework



❑ Developed prototype

- To implement the framework and test its applicability in reducing the energy use in the material of heritage buildings.
- A prototype is developed and used to assess the embodied energy in the applied case study.
- The prototype of the proposed framework uses Autodesk Revit as a building design tool, the Feature Manipulation Engine (FME) as the spatial ETL tool, Google Maps (GM) API as the map web service API, and Power Pivot for implementing the rest parts of the proposed framework. As shown in the Chart 2 and 3.

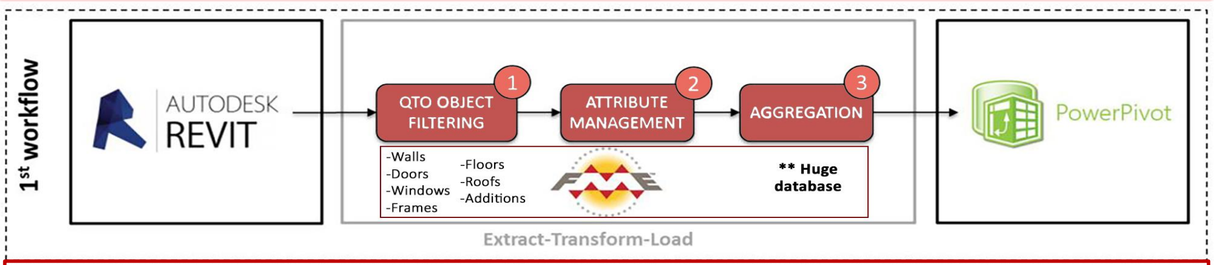


Chart 2. The developed workflow for extraction of the quantities from BIM tool . Source: (Researcher,2024).

- The EPD inventory compiles data on the embodied energy and environmental performance of various materials.
- The Building Part Library (BPL) extends the CL concept to a larger scale, containing "recipes" for entire building parts.
- The Component Library (CL) houses predefined "recipes" for building components.

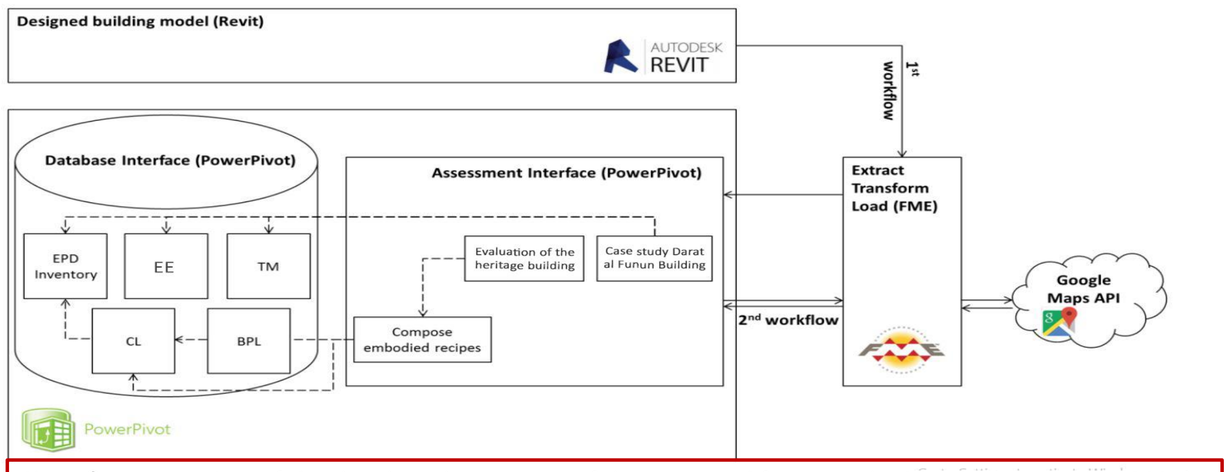
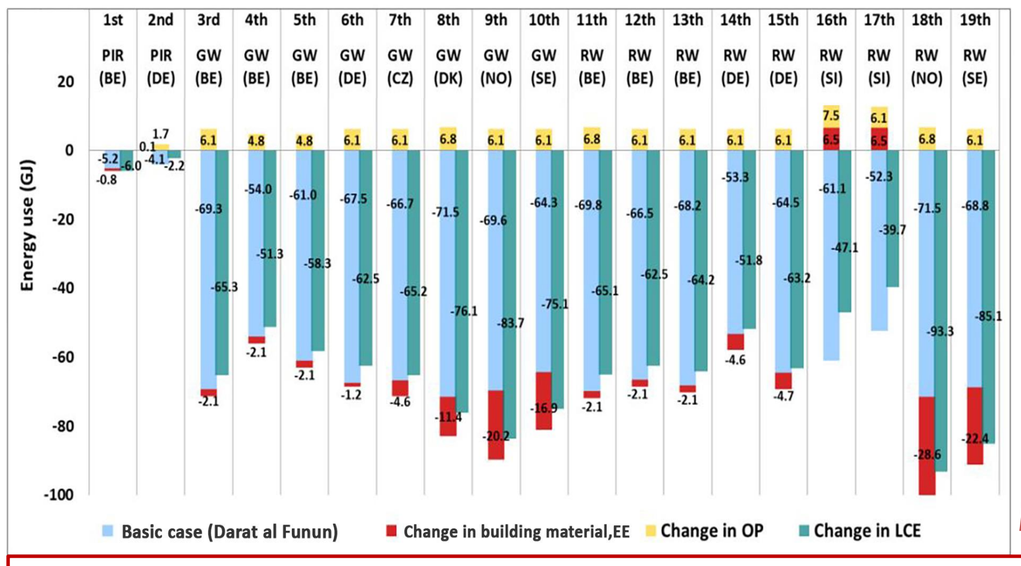


Chart 3. An overview of the developed prototype of the proposed framework . Source: (Researcher,2024).

RESULTS & DISCUSSION

➢ All scenarios were evaluated using the parameters outlined in Table 1,and chart 4 .

No.	Parameter	Value
1	Local material (Stone)	7% for all the insulation materials
2	The proximity or distance of the site from available building materials	For the distance 34 km (About the city of Salt, which is the source of the stones in which the Darat al Funun building was built)
3	Means used to transport materials	Embodied energy (Traditional vehicles and carts) = 10.7 a(MJ/L)
4	Transport	Average embodied energy = 0.11c (MJ/t.km)/ Average CO2 emission = 0.021d (kgCO2e/t.km)
5	Capacity utilization (including empty return)	90 % of the capacity in volume- 20 % in the empty return
6	Volume capacity utilization factor for all insulating materials	2
7	The lifespan of the heritage buildings	90-100 years



The assessments indicated that using GW or RW as the insulating material rather than PIR significantly reduced the heritage building's embodied energy.

Chart 4. Energy assessment results: minus signs indicate energy savings, plus signs indicate increased energy use compared to the base case.. Source: (Researcher,2024).

CONCLUSION AND FUTURE WORK

The research develops and tests a framework for assessing embodied energy in heritage building materials using Darat al Funun in Old Downtown Amman.

- This framework includes predefined recipes in a database
- Integrates BIM for energy assessments

Uses ETL technology for BIM-LCA interoperability to reduce manual errors.

- It emphasizes transportation impacts
- Promotes eco-efficient materials

Influences supplier competition and green supply chain practices, proving valuable as a decision-support tool.

Further research is needed to validate findings in real projects

- Develop the prototype for industrial applications
- Address on-site construction impacts and procurement costs