SUSTAINABLE HOUSING IN THE ARCTIC

An environmental comparison of four alternatives for building in the arctic

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INTRODUCTION

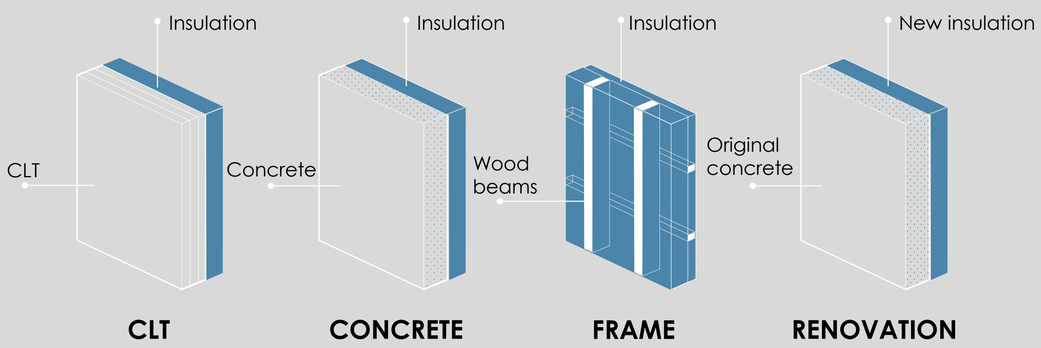
- To achieve the UN's Sustainable Development Goals (SDGs) it is necessary to take global actions, especially for **SDG no. 13 on climate change**. Construction and use of buildings in arctic areas is related to this goal.
- Environmental conditions in arctic areas mean that specific requirements are needed for buildings to provide a sufficient building envelope for people.
- Findings from existing environmental life-cycle assessments (LCAs) which mainly consider buildings in Europe and North America are not representative for arctic areas.
- Thus, **location specific LCAs are needed** to identify environmentally optimal building practice in arctic regions.

OBJECTIVES

The objective of this study was to answer the following questions for apartment housing in Nuuk, Greenland:

- Which building strategy – new cross-laminated timber (CLT), new concrete, new timber frame or renovating an existing concrete structure – has the lowest environmental impact?
- Will adding more insulation to the building envelope decrease or increase environmental impact?
- What is the environmental impact of building component transportation to the building site?

METHODS

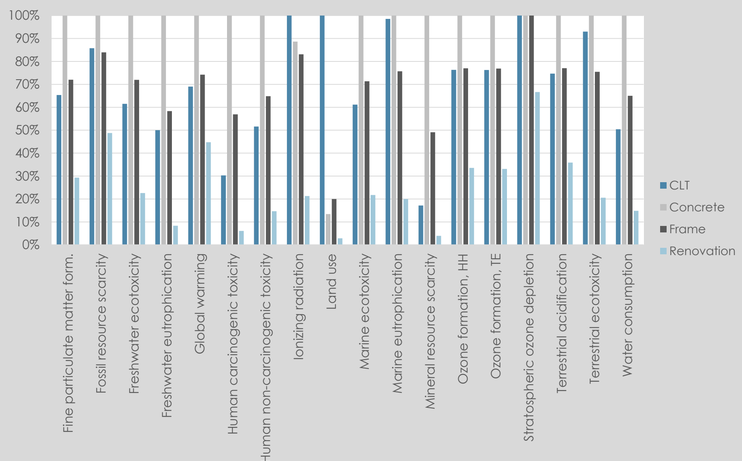


- We compare **four different building strategies**, three where a new building is constructed and one where an existing concrete building is renovated.
- We assumed that except for the building envelope and slab, all four buildings are identical (windows, foundation, roof etc.).

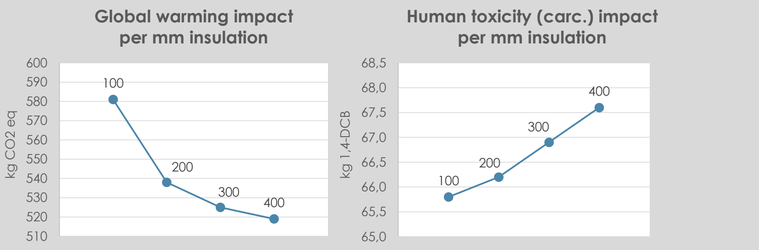
- We applied **life cycle assessment** (LCA), an ISO standardized method.
- In LCA the environmental impact of a product or system is considered from cradle to grave and aggregated into a single score of **environmental impact potential.**
- As a basis for the comparison of the four building strategies we defined the **functional unit** as:

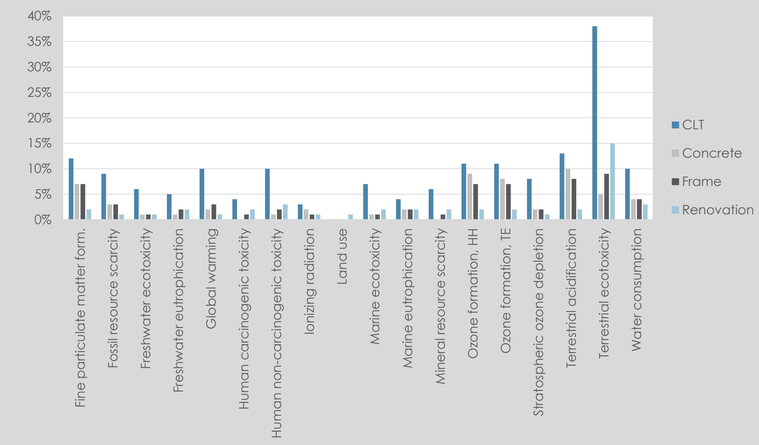
  "Construction, use and disposal of 1 average m^2 of a dwelling in Greenland, with a service life of 30 years"
- Life cycle impacts of the four different building strategies are modelled in the software **OpenLCA** using **ReCiPe 2016** as impact assessment method and **ecoinvent 3.4** as database for the background system.
- The background system is modelled using average processes.

RESULTS



- **Renovating an existing concrete structure has the lowest environmental impact** across all impact categories.
- The CLT structure has lower enviromental impacts than the concrete and frame structures in 12 impact categories
- The concrete structure has the highest global warming impact (~538 kg CO_2-eq/m^2).





- Focusing on two impact categories, global warming potential (GWP) and human toxicity, carcinogenic (HTC), the figures to the left illustrate the impact of adding more insulation to the **concrete structure**.
- While GWP will decrease when more insulation is added, HTC will increase.
- The former can be explained by a decrease in heating demand when insulating more, while the latter is caused by increased production of insulation materials.

- For GWP transportation has the highest impact for the CLT structure, ~9% of the total. This is caused by the large amount and weight of the CLT elements.
- For the concrete, frame and renovated structure, transportation is ~3% of the total impact.

CONCLUSIONS

The following conclusions can be made from the results obtained:

- Renovating an existing structure has the lowest environmental impact. Of the new building structures, the CLT structure has the lowest environmental impact in the majority of impact categories.
- Adding more insulation will decrease global warming impact, but increase human toxicity (carcinogenic) impact.
- The impact of transportation is ~9% of the total impact for the CLT structure, but negligible for the concrete, frame, and renovated structure.

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