Newsletter 7 | March 2023

Climate Challenge Laboratory | Building 313

The biggest CO_2 savings are in the details

Theme: Materials and building systems

DTU Campus Service
Danmarks Tekniske Universitet

The biggest CO_2 savings are in the details

If you want to reduce energy consumption in new construction, it pays to go to the margins and minimize quantities and layers. In the Climate Challenge Laboratory's design process, Christensen and Co Architects gotten new knowledge of and experience with materials. Life cycle assessments have been a central tool.

Buildings, bridges, and roads account for 30% of Denmark's CO_2 emissions. 10% of the emissions comes from the production of building materials and the building and construction processes. That is why DTU focuses on materials in the design of the Climate Challenge Laboratory.
In this newsletter, partner Michael Werin Larsen and project manager Tobias Wittenburg, both from Christensen and Co Architects explain about how they have sought the most sustainable solutions possible when building a high-tech laboratory building.
The consequence is a series of new initiatives. Most visible is the choice of wood for the load-bearing structure in the office part of the building. In addition, the team has qualified the choice of materials and optimized the quantities and layers in structures, for example the facade. Life cycle assessments have been an important tool in both the design process and as a decision-making basis for DTU Campus Service.
At the end of the newsletter is information about when there will be noisy activities on construction site, a status of the construction project, and contact information.

CO_2 in focus. In the development of the Climate Challenge Laboratory, Michael Werin Larsen, who is a partner and MA Construction Management, and Tobias Wittenburg, who is project manager and Arch. Tech & Const. Management MAK at Christensen & Co Architects, have continuously calculated the CO_2 emissions of materials and building systems. Photo: Christensen & Co Architects

" : It is not a *walk-in-the-park* to work with sustainability in construction. Not at all in a heavy, complicated house where we must comply with a number of functional requirements."

– Michael Werin Larsen, partner, CCO

A two-legged strategy
There are many requirements for a seven-storey research building. Nevertheless, DTU CAS and Christensen & Co have consider sustainability in all choices. An important tool has been LCAbyg, which calculates buildings' CO_2 emissions, and LCA calculations have guided Christensen & Co Architects in the design process and has served as a decision-making basis for DTU.

ML: It is not a *walk-in-the-park* to work with sustainability in construction. Not at all in a heavy, complicated house where we must comply with a number of functional requirements. You cannot compare it to e.g. a residential building in Ørestaden. We are building a high-tech laboratory building. This limits the options we have in relation to sustainability.

TW: That is why we have chosen to focus on two aspects. One is to qualify our choice of materials so that we make the most sustainable choice in relation to what is necessary to comply with requirements. And the second is to minimize layers and quantities.

How have you qualified your choice of material?
TW: When we have made choices, we have looked at the material pyramid, LCA calculations, and we have consulted with suppliers and so on. There are many

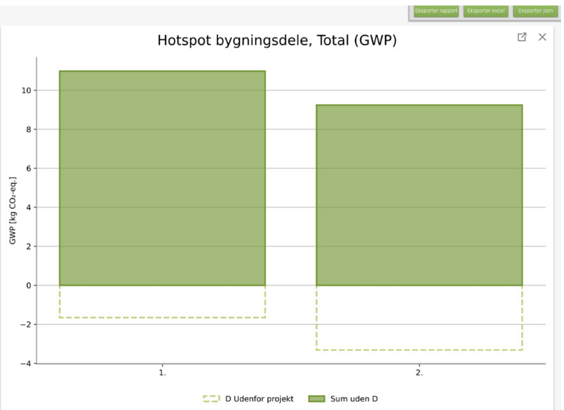
things that have an impact on the most sustainable choice is within the framework.
During the detailed design, we have created a small LCA analysis many times, where we have compared two different materials to make a choice. Here we have used the tool actively, just as we can look up a table or check a reference.

ML: LCA calculations have become a part of our method. It takes maybe 20 minutes to do a LCA calculation at building component level and then we can quickly clarify what is the right thing to do. We learn from this. At some point we also just know that one material is better than the other. We will have that experience.

Are there examples where the LCA calculations have been decisive for material selection?
TW: In some places, the materials have been chosen according to DTU's design guide. Elsewhere, we have chosen based on LCA analyses.
At some point we had to find an alternative to the wooden slatted ceilings we had initially chosen. Here, the LCA analysis pointed in the direction of cement-bonded wood wool being more sustainable than the mineral wool boards that DTU mostly uses. At the same time, we made an LCC calculation, i.e. a total economic assessment, on the two materials. This gave us and DTU two calculations that supported each other and functioned as a decision-making basis, so the choice fell on cement-bonded wood wool, which is new at DTU.

Where else have you been able to introduce new solutions?
TW: We came across eelgrass from Søuld (frontpage) when we were investigating acoustic solutions for the large atrium. The common materials for acoustic solutions are based on mineral wool batts, which are made of glass or stone and fired at high temperatures. Eelgrass is sustainable on various parameters.
It is a natural product that washes up on the beach. If it isn't removed and it goes back into the sea, it pollutes the marine environment as rotten plant material. So removing it from the beach is a good story. And because it is grown in salt water, it is naturally impregnated against fire, and therefore it is possible to produce and use this product.

Another example is the aluminum facade. Aluminum is normally "bad", but we have delved into the material and qualified how we use it. We found that some types of surface treatments mean you must use 100% pure aluminium. With other treatments, you can use less clean material, i.e. recycled aluminium. So instead of using anodised



Basis of decisions. LCA and LCC analyzes were the basis for DTU's decision to use cement-bonded wood wool for the ceilings. It is a robust material that can be composted. Photos: Christensen & Co Architects/Troldtekt

LCA & LCC

LCAbyg 2023 is a free tool that calculates life cycle assessments (Life Cycle Assessment) for buildings. With LCAbyg, you can calculate a building's environmental profile and resource consumption. The calculation covers the entire life cycle of the building and therefore includes procurement of raw materials, production of building materials, energy and resource consumption during operation and maintenance, as well as disposal and possibly recycling of building parts and building materials.

LCCbyg is a tool that calculates total economy (Life Cycle Costing) and produces a clear overview of lifetime costs for an entire building and for individual building parts. LCCbyg can i.a. help decision makers compare two or more alternatives that have different cost profiles over time.

Source: LCAbyg.dk/LCCbyg.dk

aluminum sheets, which is a chemical way of treating aluminium, we have chosen lacquered aluminum sheets. This means we can use recycled aluminum instead of newly produced aluminum. Here we only pollute with 2.5 kg. CO_2 against 11 kg. CO_2 with new aluminium.
So we have done that on all the materials we use in large quantities: qualified how we use them.
There are savings to be had in building systems Requirements, especially fire requirements, set restrictions on which materials can be used in the Climate Challenge Laboratory. Therefore, we have looked at how the facade and floors are constructed. These are often large surfaces where, with few resources, large amounts of material can be saved - and thus CO_2.

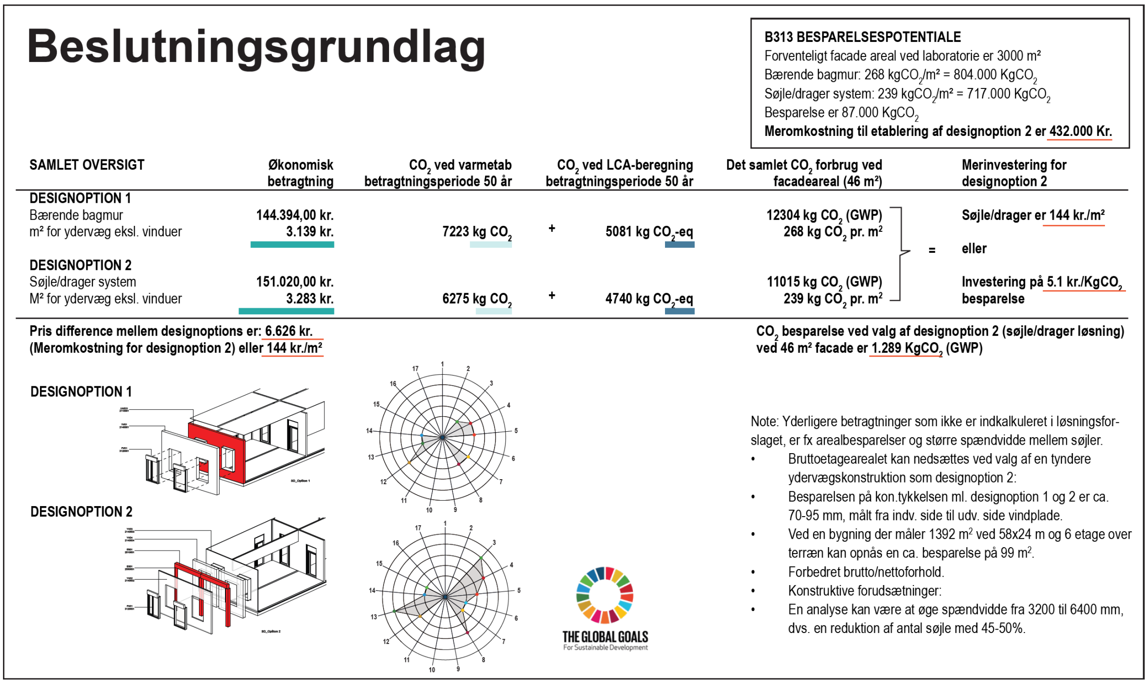
Where have you had the opportunity to minimize the amount of materials?
TW: Architecturally, the building abuts the B310, so therefore the facade had to be aluminum. The B310 is made with a double facade. This means that there is a closed climate shield on the inside behind the aluminum perforated plates, which become an architectural element. We have had to keep that motif so the two buildings corresponded, but in the Climate Challenge Laboratory we have optimized the layers. Among other things, we have used smaller aluminum facade panels as an architectural element, and so the double facade only covers 30% in the Climate Challenge Laboratory.

ML: Yes, and then we optimized a lot on the thickness of the aluminum plates. The amount of kg of aluminum used is significantly reduced compared to B310. We have chosen a 2 mm aluminum plate rather than 3 mm. Before, you might not have thought much about the difference, but we save 50% in material consumption. It is a way of thinking about quantities. The thickness of the materials.
Another good example is the subfloor. It is typically 100 mm concrete. There we learned in B310, after a dialogue with the contractor about tolerance requirements and buildability, that we could get it down to 80 mm concrete. After all, it is 25% on 10,000 m² that we save. It is a layer you can do less.

TW: Another example is that at DTU there are no ceilings in the laboratories. It is also a large amount of materials that can be avoided in construction.

Where have you encountered barriers?
TW: Insulation is the material we use the most - and there we are tied hand and foot due to fire requirements. There is only one product we must use: stone and glass wool, which is the traditional insulation material.
There are some manufacturers who are working on recycling within insulation, so that it is more sustainable today than five years ago. But we can't do it with seashells or anything else exciting because that's just not allowed.

ML: Another thing is interior walls. We have many partitions and the construction must be in steel, but they could as well have been in wood, which can do the same things. It is especially the fire requirements that dictate those choices.


Beslutningsgrundlag

B313 BESPARELSESPOTENTIALE
Forventeligt facade areal ved laboratorie er 3000 m²
Bærende bagmur: 268 $kgCO_2/m^2$ = 804.000 $KgCO_2$
Søjle/drager system: 239 $kgCO_2/m^2$ = 717.000 $KgCO_2$
Besparelse er 87.000 $KgCO_2$
Meromkostning til etablering af designoption 2 er 432.000 Kr.

SAMLET OVERSIGT	Økonomisk betragtning	CO_2 ved varmetab betragtningsperiode 50 år		CO_2 ved LCA-beregning betragtningsperiode 50 år	Det samlet CO_2 forbrug ved facadeareal (46 m²)		Merinvestering for designoption 2
DESIGNOPTION 1							
Bærende bagmur	**144.394,00 kr.**				**12304 kg CO_2 (GWP)**		**Søjle/drager er 144 kr./m²**
m² for ydervæg eksl. vinduer	**3.139 kr.**	**7223 kg CO_2**	+	**5081 kg CO_2-eq**	**268 kg CO_2 pr. m²**		
						=	**eller**
DESIGNOPTION 2							
Søjle/drager system	**151.020,00 kr.**				**11015 kg CO_2 (GWP)**		**Investering på 5.1 kr./$KgCO_2$**
M² for ydervæg eksl. vinduer	**3.283 kr.**	**6275 kg CO_2**	+	**4740 kg CO_2-eq**	**239 kg CO_2 pr. m²**		**besparelse**

Pris difference mellem designoptions er: 6.626 kr.
(Meromkostning for designoption 2) eller 144 kr./m²

CO_2 besparelse ved valg af designoption 2 (søjle/drager løsning) ved 46 m² facade er 1.289 $KgCO_2$ (GWP)

DESIGNOPTION 1

DESIGNOPTION 2

THE GLOBAL GOALS
For Sustainable Development

Note: Yderligere betragtninger som ikke er indkalkuleret i løsningsforslaget, er fx arealbesparelser og større spændvidde mellem søjler.
- Bruttoetagearealet kan nedsættes ved valg af en tyndere ydervægskonstruktion som designoption 2:
- Besparelsen på kon.tykkelsen ml. designoption 1 og 2 er ca. 70-95 mm, målt fra indv. side til udv. side vindplade.
- Ved en bygning der måler 1392 m² ved 58x24 m og 6 etage over terræn kan opnås en ca. besparelse på 99 m².
- Forbedret brutto/nettoforhold.
- Konstruktive forudsætninger:
- En analyse kan være at øge spændvidde fra 3200 til 6400 mm, dvs. en reduktion af antal søjle med 45-50%.

Living up to new standards. In the tender, DTU CAS requested new sustainability solutions. Christensen & Co Architects offered to take on the consultancy task with a proposal to carry out LCA analyses. It was in 2020 before demands were made for use of the tool. The offer included an LCA analysis of the load-bearing system in columns or in a rear wall. Photo: Christensen & Co Architects

If we had built a small family house, we could have several small sustainability success stories, because the requirements for single-family houses are simply less than for complex research buildings. We are limited to optimize on quantities and layers - and choosing the right way to use a material that might otherwise not be so good.

You have designed ten buildings for DTU since 2009. In 2022 you did LCA calculations of the facade solutions, what have you found out?
ML: We have calculated the outer walls of the projects so that we can compare them and now we have a representative sample of different structures. The study shows the amount of CO_2 we use per square meters when we build an outer wall including the load-bearing structures. And there is a lot to be gained from the facades and our study shows that external wall constructions can vary by up to 25 0% in CO_2 consumption per m^2.

So where the material pyramid and the EDP focus on the individual material, are you looking at a coherent structure, as a form of standard design?
ML: Yes, when you just look at the facade plate itself, it doesn't matter. That is my claim. It may be able to do a little, but there is still everything else, for example the supporting system and the suspension. That is what you should try to challenge. It is complicated because there are also parameters other than CO_2 that come into play. Economics, of course, but also the working environment and durability.

New requirements for CO_2

On 1st of January 2023, the Danish government introduced requirements for LCA calculations for all new construction projects. For new buildings over 1,000 m^2, a requirement for a CO_2 limit value corresponding to 12 kg CO_2 eq/ m^2/year is introduced. The requirement applies to all new buildings covered by the energy framework. The requirement can help to reduce the climate footprint from construction projects and mature the industry and developers to build more sustainably and promote climate-friendly solutions in the construction industry.

As a voluntary option for the industry, a low emission class will be introduced in 2023 with a limit value corresponding to 8 kg CO_2-eq/ m^2/year, which will be tightened in the years ahead with fixed limit values in 2025, 2027 and 2029.

Christensen and Co Arkitekter expects the Climate Challenge Laboratory to emit 11.7 kg CO_2-eq/m^2/year.

Source: Housing and the Danish Planning Agency/CCO

With new materials and methods comes new experiences

The consistent focus on the materials' CO_2 emission has offered new experiences and insights.

The Climate Challenge Laboratory's office part will be built as a wooden structure. What have you learned so far?
ML: We did a calculation on a wooden house and a concrete house to find out if there was a saving. The preliminary saving was approximately 50%. Subsequently, we have screened various suppliers on their EPD data, i.e. their products' CO_2 values, to find out how the suppliers perform. It showed that there was a huge difference in what the suppliers can do. The EPDs really have a lot to say.

So the material itself is not enough?
ML: No, it's also about how the material is produced, how elements are manufactured and transported... That has an impact. It's really something that developers, advisers and contractors have to get to grips with and then find out how the market works.

What else have you experienced?
ML: In relation to the wooden house, it was an eye-opener that it pays better to build a tall wooden house - that is, over 22 m - than a low one, which is anything under 22 m. Climate Challenge Laboratory will be 30.7 m. Today you must have the same fire technical installations regardless of whether you build in concrete or wood. Then the business case starts to be comparable when you build high, regardless of whether you build in wood or concrete. When you build a low wooden house, you must have more fire-technical installations than in a low concrete house. And it will be expensive in installations – both financially and in terms of CO_2.

TW: There are also some norms that have not followed along with the reality. Building in wood is so new that there is no precedent. The construction engineer looks in the concrete standard for what must apply. The industry is not involved. The old language is used to describe a new material.

ML: We have also learned that when it comes to authorities or constructions, it is not difficult to

EPD

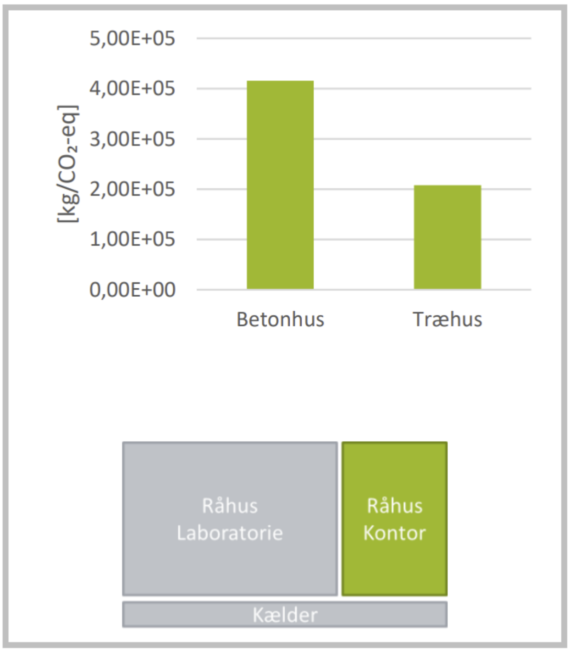
An EPD (Environmental Product Declaration) documents the environmental properties of a construction product. The EPD is a standardized method for providing information about a building product's energy and resource consumption, waste generation and the environmental impacts from its production, use and disposal. The basis for an EPD is a LCA calculation, where the environmental properties of the construction product are mapped throughout its life cycle. In principle, this means from cradle to grave.

Source: Epddanmark

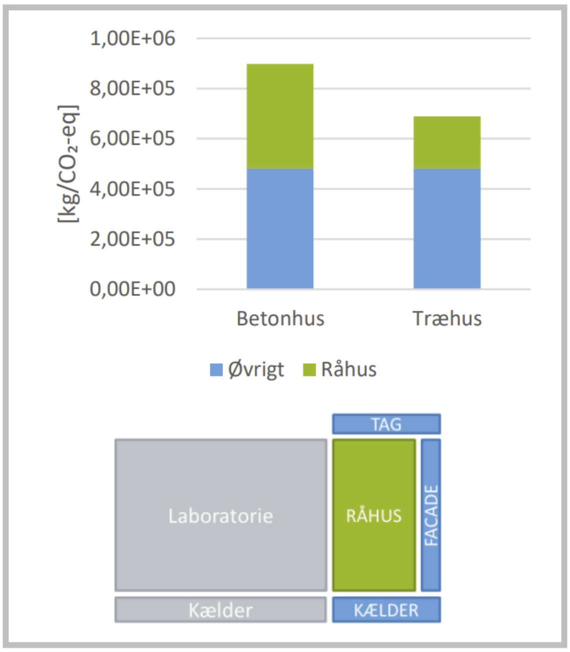
build a wooden house. So far it hasn't caused us any problems. There are some advantages to that. The process has given us an insight into what you can do. We have now gone through the design phases. Now there are two stages left, construction and operation. We must learn that now how It work in those phases.

Is there anything you took with you?

ML: There are many things that are an eye-opener for me, especially having to get to know the materials in a completely new way. For example, what is the difference between MDF, OSB and plywood? We know something about the construction technique in it, what the materials can do, how much they cost and where you use the various things, but in relation to CO_2 I learned new. I had no idea, but here the calculation showed that there are some choices you can make. We must learn something new there. Even though they are completely common building materials. And I think that can change your approach.

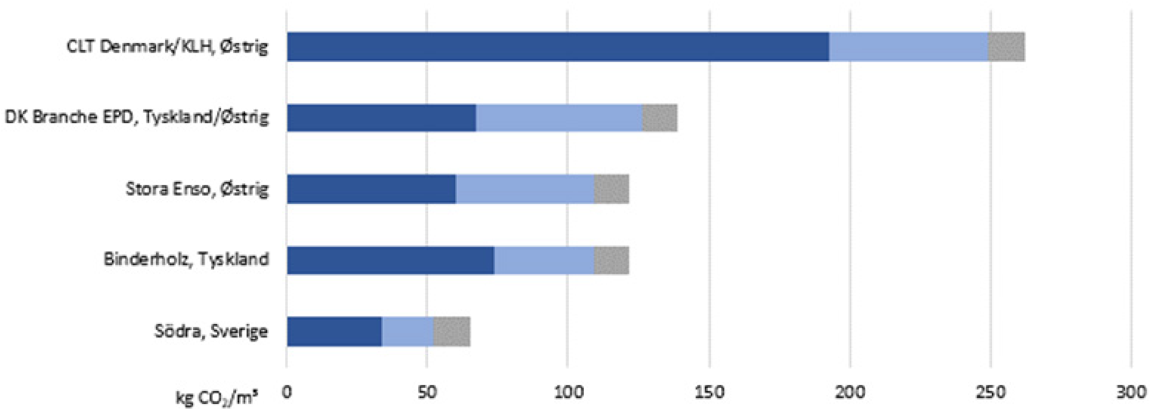


Figur 1. Klimapåvirkning fra råhus i kontordel. Forskel på 208 ton CO_2eq.



Figur 2. Klimapåvirkning fra kontordel. Forskel på 208 ton CO_2eq.

EPD makes the difference. Christensen & Co Architects and MOE-Artillia Group did an LCA calculation on a wooden house and a concrete house to find out if there was a saving. The preliminary saving was approximately 50%. Subsequently, they screened the EPD data of the five suppliers, which showed that the EPDs are very important. The image below shows CO_2 emissions for each CLT-producer with production (dark blue), transport to building site (light blue) and End-of-life (grey). Photo: Christensen and Co Architects



Basic information

Construction work
The interior work in the basement is fully underway and the concrete super structure is already well up in height. Before long, the assembly of the CLT wood constructions will begin.

Status of the project
The consultants have just handed in the end-user project. DTU CAS is in the process of developing the interior design project with advisers and end users.

Contact information, DTU CAS' project team
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Time schedule

Winter 2020/2021	Spring 2021	Late summer 2021	Autumn 2021	Winter 2021/2022	Spring 2023	Summer 2024
Project Start-Up	Program	Outline proposal	Project proposal	Execution project	Construction on site	Users move-in

Construction site