Deliverable 6

Project summary

Celcius HU
www.Celcius.house

Celcius@hu.nl

Bolognalaan 101
3584CJ
Utrecht

Preface

Right now, the housing sector in the Netherlands is experiencing pressure. The growing population makes it difficult to find a home, especially for young people. We are young, innovative and environmentally aware people, thirsty for finding a long-term solution. That's why we're building a sustainable house within (financial) reach for everyone. In the entire lifecycle we reuse as much materials as possible, we store and reuse energy and rainwater. Our house is completely modular, and thus sizeable from a starters version up to a five-story building. Everything comes together with Celcius.

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1 Design philosophy

1.1 Modularity

The philosophy that has been the base for our entire concept is the modular approach. By incorporating a modular approach into our way of thinking we have changed our design process radically. We have been aiming towards simplifying the building elements to create a standardized building method that shocks the building industry because it is unlike anything it has ever seen. Our concept is like Lego, this toy consists of standardized blocks which, when combined, make up all sorts of buildings. The same goes for our concept. The core of our house consists of a wooden frame to which all of the Lego like wall and floor panels will be attached. Add-ons such as a finish are considered separately so the resident can personalize the house to their needs and preferences. The benefits deriving from a modular way of building and thinking are almost endless: adding rooms, enlarging rooms, downsizing, upgrading, relocating. In a traditional constructed building, these processes are either highly cost intensive, time intensive or impossible. With a Celcius house all of this can be easily done without complicated building processes.

1.2 Circular Economy

Our concept is based on the principles of the circular economy. We are aiming towards a building concept that has the lowest environmental footprint as possible. We are doing this by creating a building method that is a closed loop in which raw materials are reused without losing their value. The concept focuses on reusing materials instead of the current take, make and dispose economy.

Since the house is modular, all elements can be easily detached from the house. That way elements won't get damaged by disassembly so they can be reused while keeping their highest value. All material choices have been made with the impact it has on the circularity and modularity in mind.

1.3 Energy & sustainability

The Trias Energetica is a model that acts as a guide when pursuing energy sustainability in the building sector, it is developed by the Delft University of Technology. This model makes clear that energy savings come first in our journey to a environmental friendly building. Only when a building has been designed to minimize energy loss, there should be a switch in focus to renewable energy solutions instead of fossil fuels. Lastly when there is no other possibility, fossil fuels should be used and produced as efficiently as possible. When designing our house we started with the first step of The Trias Energetica by insulating the house in a way that there is a minimal energy loss. Which means we need to generate less energy. The house doesn't use any fossil fuels so all of the energy it uses has to be generated by the house it self.

2 Unique house features

Every ambition starts with a challenge that we pose ourselves. Because of the critic point the housing market has reached in The Netherlands, we had to come up with an idea that can solve the problems of each and one of the people in our target group. So, we made a sustainable, life-lasting home within (financial) reach for everyone.

2.1 Evolving to sustainability

We believe that the only way to become a sustainable community is through evolution. That is not a quick or easy process, but we already see that happening in our approach to the design of our house. We build the frame, floor-, ceiling- and wall-panels out of wood, which not only makes you happier than other types of materials but can also be produced in a sustainable way. We insulate those panels with organic materials that are chemically hardened so that we can become part of a circular economy. The way energy from the solar panels is stored inside a battery makes the house self-sufficient for three days in case of power outage and we strive to make it neutral on the network capacity in normal situations. You can choose to incorporate an air-water heat pump that can keep the temperature stable, and you can choose to collect rainwater to use for the shower, toilet, your coffee machine or the garden. You can also have a smart system installed that regulates power usage on its own and prevents spoiling power. You can even add a vertical garden to your facade to make it attractive for bees and other insects. Or you can have all of those features.

2.2 Modularity and adaptivity at the core

Because we know that evolution is a long and sometimes tedious process, we designed the house to be modular, and thus adaptive to your specific life needs. By standardizing the production process of the structural elements and designing our own screw-less fastening system we make our home into something like a LEGO set for adults. After building the house, which can be done in less than 6 weeks, it can grow and shrink in size without the need to have the expansion engineered by a building company. And the fact that every component and system is removable and interchangeable, every room scalable and every pipeline movable makes that our target client can start living in a relatively simple version of the home, only to upgrade it later in life. Adding a new room, a whole new story or removing it is easily achievable. When you don't need the room anymore, you can even trade it with another Celcius-home owner. This is not only reinforcing the circular aspect of the house but is also making it a life-lasting living opportunity.

2.3 Being economically friendly

The modularity of our concept makes our design adaptable to the life needs of the dweller. We also want to make it as easy as possible for our potential customer to literally configure their own house. That's why we're currently researching the housing market to discover what our target groups' needs and wishes are. Our goal is to have different standardized modules of the Celcius house ready to be loaded in a configurator app or website. This tool allows a potential customer to build their own house out of these modules and directly see what it's going to cost them. The fact that the house can be easily up- or downgraded over time in its systems and its rooms enables the house to go hand in hand with the needs and situation of the dweller.

3 Innovations

To create a house which is sustainable, modular, life-lasting and also scalable we need to be innovative on many different disciplines. Every product that has been incorporated in our design is carefully researched and valued. We have been engineering with our core values in the back of our minds. So with every new decision we have been asking ourselves over and over again if these drawings represent our vision. And when the answer is 'no', we are re-engineering until the drawings represent our vision.

3.1 Architectural

To make our house as sustainable as possible our goal to is not only use materials that can be reused by recycling but to design our house in such a way that all materials can be reused without the need of recycling.

Our structural frame is a great example of the modularity and circularity because the wooden beams are connected without screws but with steel connectors that are hold together with pins that are hammered into them. After the pins are taken out, the beams can be reused in the same way without the need of recycling or put time/energy in the material to be able to reuse it.

To connect facade panels, floor panels and roof traditionally, this is done by using screws to hold them in place. Here we encountered a problem, we didn't want to drill or screw into our wooden beams because after multiple disassembly's this would make the wooden beam not reusable. To tackle this problem we have looked into many products on the market but we didn't find any solution to our problem. So we decided to engineer our own solution where we were inspired by a THQ-beam and the way cars are assembled.

As a result we came up with a bracket which slides over the wooden beam so it becomes a THQ shaped bearing beam. With this solution we were able to place our façade panels on one side of the bracket and a floor or roof panel on the other side, without damaging our construction. We then engineered holes which make it possible to align every panel on the correct position and then bolt it all together. By assembling our house this way the structural frame and panels can be reused without the need of recycling.

3.2 Mechanical engineering and water management

To limit our energy usage we have engineered a very efficient low temperature heating system. This system uses the newest convection radiator to transfer heating and cooling throughout the house. Because of our efficient design and placement of our radiators we are able to create a optimal air flow circulation which lowers our energy usage drastically.
For our HVAC system we use a state of the art all-in one module that includes a hyper efficient heatpump with a SCOP of 5,3 while only producing 40 Db of sound, it also recovers heat from our outgoing air to our incoming air. Our system is able operate in extreme conditions. It can maintain an inside temperature of 20 °C while outside temperatures vary from -10 °C up to 45 °C. The system is fully integrated into our house without the need of an outside module. The entire module is able to maintain energy demands when the house expands and therefore futureproof.

In order to use water as efficient as possible we have integrated a revolutionary shower which filters and reuses the water from its drain. By using this technology we are able to decrease the water usage of the showerhead to 1,5 liter per minute. Combined with our efficient piping design to decrease the water travel distance we keep our water usage as low as possible.

3.3 Home automation

It began with the first smartphone, a small device which should make our lives much easier. Nowadays almost every electric product on the market can be “smart” like your phone, but all those products are designed on a different platform and we need to install a lot of different apps for each brand. Wouldn’t it be much easier if we had one app to communicate with all those devices in our home? Well that is what our home automation team is doing, it might not be as visible as all the other innovations but it will definitely be a lot more straightforward to combine all of the “smart” devices into one smoothly running system. This also gives us the benefit to collect data which can be used to do research to further improve our concept and it will enable the house to adapt to the behaviors of the dwellers.

3.4 Insulation material

Another large innovation that is incorporated into our concept is the material that is used to insulate the walls. Our house will be the first house that is built using this material. What’s so special about this material is the fact that it is made out of organic waste. Instead of throwing away this organic material, it is used to create a mycelium that performs as well as mineral wool insulation materials. Which manufacturing processes can be largely energy intensive creating an enormous strain on the environment. The mycelium used in our walls can be manufactured without any additional energy since it is formed by biochemical processes which don’t require anything but air. A fluid is placed inside the wall panels, after curing a solid material remains that is made entirely out of bio-based materials.

4 Target client

4.1 The customer, the design and the market needs

The target customer is actually not one customer, but two, a 25-35-year-old (Vries, 2016) couple who want to buy their first home. This is a large group in the Netherlands, but there aren't a lot of houses available on the market. (Vrieselaar, 2019). The market is at its peak in price and therefore buying your first house is extremely difficult.

The couple wants to be able to personalize a house, so that the house will feel 'of their own' and will become their home. Furthermore, the target group has been triggered by sustainable living and they consider circularity, modularity and self-sufficiency important. Those four aspects are offered by the Celcius house.

4.2 Target market

The distinctive character of the Celcius house compared to the competitors in the Dutch housing market is its combination of circularity, modularity and affordability. This makes the Celcius house a unique concept.

The house is circular because the elements can be used in other houses. So, reuse of elements is possible. Furthermore, an insulation material is used that consists of residual material from the food industry. By using standardized measures, the elements can be exchanged, and modularity is achieved. The elements are fixed to steel profiles, so the connection can be completely disassembled again. So only detachable connections are used.

The distinctive character with modularity and affordability is therefore the ultimate combination for the market and the costumer Celcius wants to serve. But also, the combination of modularity and affordability combined with self-sufficiency and circularity is extremely important for the target market but is therefore more expensive.

The couple thinks it is important that no energy is lost. They want to generate the energy themselves to ensure that it is sustainable energy. Sustainability is also important to the couple because the world is getting worse due to global CO2 emissions. They want to do their part to reduce emissions. Reducing those emissions starts with changing your daily habits and therefore with your home.

5 Team organization

Name	Email address
Arnoud Draijer	arnoud.draijer@hotmail.com
Sarah Hasselman	Sarah.hasselman@hotmail.nl
Jelle van Rossum	jjvanr@xs4all.nl
Huib van Balom	huib.vanbalkom@student.hu.nl
Lorenzo Gentili	Lorenzo.g@me.com
Tim Harte	tim.harte1997@gmail.com
Rutger Kroeze	rutgerkroeze@hotmail.nl
Mike Zuydendorp	mike.zuydendorp@student.hu.nl
Rens Morsink	rensmorsink1@gmail.com
Mike Steenkamer	mike.steenkamer@student.hu.nl
Linda Huisman	linda.huisman@student.hu.nl
Rowin van Schaik	rowin.vanschaik@student.hu.nl
Lucas Bijvoet	lucas.bijvoet@gmail.com
Marnix Laumen	marnix.laumen@student.hu.nl
Andy Huynh	andy.huyn@student.hu.nl
Bram Vissers	vissers1998@outlook.com
Erwin Koelewijn	erwin-koelewijn@hotmail.com
Bart Duister	bartduister@hotmail.com
Pim Bassie	Pim.bassie@solcon.nl
Sam van Amsterdam	sam.vanamsterdam@student.hu.nl
Ole Agterberg	oleagterberg@gmail.com
Wessel Henkes	wessel.henkes@student.hu.nl
Gigi Bikker	gigi-bikker@hotmailcom
Roel Gremmen	roelgremmen@live.nl
Martijn Bosch	mathijs.bosch@gmail.com
Nidal Abdallah	nid.abdallah1@gmail.com
Gijs Weber	-
Janneke Hamers	jannekehamers10@hotmail.com
Florentine Luken	florentineluken@hotmail.com
Sigrid Broeders	sigridbroeders@hotmail.com
Joey MBO	-
Anas MBO	-
Rodrick MBO	-
Selina Hetem	selinahetem@hotmail.com
Niels Glerum	Niels@beyoubusiness.nl

6 Future plans

For the future of the house, four target segments are being investigated by a student who is doing his graduation internship. The house will participate in the Solar Decathlon Build Challenge and after that competition there will be a plan for the future. It had to be prevented that the house was only designed and built for the competition.

Research direction 1 is a learning environment for students. One of the questions that will be investigated is: "When do students learn the most in a new environment and why do the students learn more in this new environment?" Learning in the Celcius house will be a completely different experience from standard learning at a school. The students aren't getting lectures in the house, but they will use the house as a lab.

The second research direction is that companies with technology for homes can test their new products in the house. Manufacturers can find out whether the ideas they had in theory also work in real life.

The third research direction is a collaboration with HU University of Applied Sciences Utrecht and Windesheim University of Applied Sciences whether there are opportunities there. The house is being built in Zwolle, which creates the opportunity to collaborate with two schools. This allows the two schools to learn from each other and the students to learn from each other.

The fourth research direction for the future of the Celcius house is that it will be inhabited. Then various investigations can take place, for example: there can be an investigation in how the house performs technically when someone is living in the house. A lot of data is collected during such a residential test and that data can be of interest to sponsors. The data can be sold if it turns out to be of sufficient value. What should be central is whether the data is valuable or not, that must also be investigated.