The building specifications can be found online at www.zhaw.ch/iunr/kreishaus/en

Building Specifications

The KREIS-Haus ("Circular House") was designed and built according to circular economy principles. This means that the materials used, and its resource cycles largely exist in a closed loop. Wherever possible, resources have been recycled or reused. The house consists of a fully developed small living-unit and an attached multifunctional conservatory. The conservatory is a great addition to the house, and it is also essential to ensuring the overall circularity of the building. It accomplishes this by providing additional heat and sound insulation, producing solar power, providing additional living space, and enabling plant cultivation (like in a greenhouse), as well as reusing treated wastewater and recovered nutrients from faeces. All components have been built in such a way that they can be disassembled and reused or recycled at the end of their service life. All building materials are free from toxic substances, and they are either of natural origin, durable and able to be recycled at the end of their service life, or already reused or recycled. The KREIS-Haus demonstrates that it is possible to live comfortably in a reduced living space with intelligent facilities. It is a pilot research project in the field of circular building and living, which allows visitors to experience the construction techniques in practice and proved the researchers with the opportunity to collect real-life data for further research and development.

Design & Implementation

Design	The design and development of such a circular building required a fundamentally different approach to the planning of a conventional building. After compiling a comprehensive list of requirements for the KREIS-Haus with respect to the recyclability of building materials, water, and nutrients, as well as the energy cycle for heat and electricity, the building concept was developed, discussed, revised, and continuously refined. At the same time, it was necessary to find suitable products and contractors for the corresponding proposals. The products and contractors listed in this document were chosen because they met a set of criteria, and due to the fact that they were prepared to break new ground and take on risks outside of their regular day-to-day operations. These diverse requirements were incorporated into the overall concept while also retaining an openness to new ideas and creativity.
Execution plan	The execution plan was characterized by the design details. The following questions were asked for each component. How will the newly developed systems and components be installed? What will happen during the usage phase regarding maintenance and reparability? How can the building materials be installed in such a way that they can be easily removed and reused at the end of their service life? The feasibility of implementing circularity aspects was ultimately decided by the design details.
Construction monitoring	The construction phase repeatedly presented new challenges to the team. In tandem with the contractors, creative solutions were required for the installation of newly developed components due to a lack of previously existing assembly instructions. Newly discovered materials were also constantly integrated into the construction process. The mix of both professional and untrained workers on the construction site resulted in the development of simple plans and instructions that could be implemented by anyone without specialized prior knowledge. Further information about the partners: • Oikos & Partner GmbH: www.oikos.ch • ZHAW Research group Eco-technology: www.zhaw.ch/iunr/oekotechnologie

Shell Building and Surroundings

Construction site setup	The construction of the house was recorded with a webcam and documented in a time-lapse video. A multi-storey scaffold was erected for the construction of the house. • Avisec AG, Webcam: www.avisec.ch • Roth Gerüste AG: www.rothgerueste.ch
Excavation and surroundings	The circularity concept had already started being implemented at the excavation stage. The nutrient-rich soil that was derived from the excavation was reused for the rooftop garden and integrated into the house's surroundings. Different soil structures and plants now promote biodiversity in the newly created landscape. The subsoil of the building is also covered with recycled gravel. • Fritschi Gartenbau AG: www.fritschi-gartenbau.ch • Eberhard Unternehmungen, Recycled gravel: www.eberhard.ch • Elmer Maschinen + Geräte GmbH: www.elmerservice.ch
Screw foundation (concrete-free)	The KREIS-Haus was built on a screw foundation. This concrete-free foundation affects the soil structure considerably less than a conventional concrete structure. The house can also be dismantled more easily. The screw foundations can be reused or completely recycled after dismantling. • Krinner GmbH, Screw foundations: www.krinner.ch • Perez Bauingenieure GmbH: www.perez-bauingenieure.ch
Solid wood construction	The KREIS-Haus was primarily constructed out of wood. For the residential unit, natural solid wood was sourced from the Apenzell region. The wood was connected using a dowel joinery technique, which does not utilize any glue or other foreign substances. The conservatory was built using a wooden beam construction. The floors and walls are also constructed using a solid wood system without glue or metal. In the area containing the bed, the inner walls are finished in pine to allow for a deep and healthy night's sleep… • Nägeli AG, Solid wood system for housing unit: www.naegeli-holzbau.ch • Tschopp Holzbau AG, Solid wood system for the floors and conservatory walls: www.tschopp-holzbau.ch • Zisag, Overall coordination of wood construction: www.zisag-holzbau.ch
Windows	On the north, west, and east sides of the KREIS-Haus, new wood-metal windows with a Minergie-P standard were installed. The wood used for the frames is lunar wood, which was harvested during the waning phases of the moon, thus giving it its high-quality properties. The windows are tripled glazed and different woods were used for the window frames for demonstration purposes (spruce, oak, larch, pine). Two windows are also equipped with SunPattern glass. Thanks to the special geometry of the glass, passive sunlight can pass into the interior in winter, whereas in the summer it is shaded in order to keep the building from overheating. On the south side, wooden windows and doors were reused from a demolition in the nearby area. To achieve maximum insulation with the recycled materials, quadruple glazing was achieved by installing two double pane windows, one behind the other. As a result, the final structure has the insulation value of a triple-glazed window. • Schreinerei Schürpf GmbH, Windows on east, west and north side: www.schreinerei-schwyz.ch • Solar Campus GmbH, SunPattern Glass: www.solarcampus.ch • Building components agency Zürichsee-Oberland: https://www.btvz.ch

Facades	The KREIS-Haus has four different facades. On the west side, a traditional wooden shingle façade was constructed, allowing it to last a lifetime. In addition, the shingles were dipped in linseed oil, which further increased their durability. On the north and south sides, two different wooden facades were installed. On the east side, a lime plaster façade was created out of natural materials (sand, Jura- and marsh-lime and granite). This functions as a natural air conditioning system – the limestone reflects the heat of the sun and thus, the interior rooms remain cool in the summer. For the window ledges, reused stoneware floor tiles were cut and installed. • Schindelfabrik Müller AG, Wood shingles: www.holzschindeln.ch • René Frick, Façade east side
Insulation and interior walls	Only natural materials were used for the insulation; the walls are insulated with hemp wool, and the floor is insulated with recycled cork from wine bottles and wood fiber insulation boards. Wind paper protects the building from wind forces, and thus also from energy loss, while at the same time allowing water vapor to diffuse through the construction. The energy certificate was planned around the use of natural materials and meets the legal requirements. The interior walls and ceilings are partially covered with clay panels. Clay has moisture balancing qualities, and it can absorb odours and store heat. This creates a healthy and pleasant interior climate. • Stroba, Natural building materials, insulation and clay: www.stroba-naturbaustoffe.ch • BB&A Buri Bauphysik & Akustik AG, Energy certificate: www.bb-a.ch • IG Lehm, Clay construction: www.iglehm.ch • SIGA Services AG, Wind paper: www.siga.swiss • Pro Clima Schweiz GmbH, Wind paper: www.proclima.ch

Interior Design and Furnishing

Floors	The floor in the living room consists of a reused parquet floor, which was removed from an office building and reinstalled in the KREIS-Haus. In the conservatory, stoneware tiles from leftover and scrap materials were used. The tiles were laid directly onto the wood fiber insulation board without the use of binding or sealing materials. • Tüscher Dach AG, Porcelain stoneware tiles: www.tuescherdach.ch
Doors	Two automatic sliding glass doors were installed in the interior of the house. They have a contactless feature for opening and closing. Access can be controlled individually. For the exterior doors, two large custom-made facility doors were installed on the north side, and a reused balcony door from a demolition project was used on the south side. • Dormakaba Schweiz AG, Sliding doors and locking systems: www.dormakaba.com • RWD Schlatter AG, Facility doors: www.rwdschlatter.ch
Bathroom	For the construction of the bathroom, the use of adhesives and composites was avoided as much as possible and to a large extent, recycled materials are used. For the floor and the bathroom furniture, the panels are made out of recycled glass shards. The sink is also made from this glass – no porcelain was used in the bathroom. The shower walls are made from recycled plastic and were screwed directly onto the wooden walls. The shower door is made from glass containing a sandblasted motif. The bathroom exclusively utilises high efficiency faucets, which are made from recyclable brass. The shower armature has a thermostat which maintains the

	water temperature during showering. The lavatory tap is contact-free and turns off automatically. The toilet is a so-called separating toilet. It is a dry toilet that collects urine and faeces separately with a conveyor belt. • Keramik Laufen AG, Armatures, shower tub: www.laufen.ch • Kompotoi AG, Dry separating toilet: www.kompotoi.ch • Magna Glaskeramik GmbH, Recycled glass boards for floors and bath furniture: www.magna-glaskeramik.de • Quendoz Glas AG, Bathroom planning and mounting, shower door glass with sandblasted motif: www.quendoz-glas.ch • Smile Plastics, Shower walls from recycled plastic: www.smile-plastics.com
Kitchen	The kitchen is made entirely out of steel. Since this material is very robust, it will last a lifetime. Even after several decades of use, a steel kitchen can be renovated relatively easily and can thus remain in use for many years. The kitchen is small and compact, but it contains all the essential appliances needed to provide the best possible comfort: a combination steam oven, a refrigerator, and a ceramic stovetop. • Forster Swiss Home AG: www.forster-home.ch
Bed	The ergonomic bed and its components are made entirely out of natural and sustainable materials. No plasticizers or other chemical additives were used. At the end of its service life, the individual components can be recycled. For example, the natural latex mattress can be melted and reused for tires. A lot of storage space was built into the custom-made bed frame to make optimal use of the limited space in the KREIS-Haus. • Hüsler Nest AG: www.huesler-betten.ch
Seating	In the living room and the conservatory, there are seating areas for relaxation purposes. The seating area in the conservatory is a multi-functional platform. It can be transformed into a table with benches, two beds, or a Japanese-style tea platform. The basic structure of the furniture is made from wood. For the other parts, scrap wood from a demolition as well as panels from recycled plastic were upcycled. The seating area in the living unit consists of modular building blocks made from cork. These can be assembled flexibly. Both seating areas are adaptable, which allows the limited space to be used efficiently. • Corkbrick, Cork building blocks: www.corkbrick.com • Upboards GmbH, Recycled plastic construction boards: www.upboards.ch • Multi-functional lounge: own design & construction
Decoration & curtains	For the decorations in the house, various old objects were repurposed and upcycled. High quality curtains separate the different areas of use. • Tisca, fabric for curtains: www.tiscatiara.com • Leutenegger AG, installation of curtains: www.leuteneggerag.ch

Energy and Building Technology

Solar power system	The semi-transparent solar panels integrated into the conservatory (south side) and the roof integrated solar system with skylights (north side) provide the energy for the KREIS-Haus. The 10 kWp system produces all the energy needed for the house. The house is nevertheless connected to the power grid, so that the excess electricity that is produced in the summer can be fed into the grid. The solar panels on the south side are made from laminated safety glass with triple glazing. The individual solar cells shade the glass, but still allow 38% of the light to enter the living space. The glass panels are attached to the rafters of the conservatory with clamping profiles. On the north side, there are two skylights in the solar roof. These panels are frameless, and the skylights have the same dimensions as the panels, thus blending in well with their surroundings. Reused metal was used for some of the sheet metal on the roof. • Energie Netzwerk GmbH, Planning of solar power system: www.enetz.ch • Swisspearl Schweiz AG, Solar modules on north side: www.swisspearl.ch • Ertex Solartechnik GmbH, Solar modules on south side: www.ertex-solar.at • RAICO Swiss GmbH, Clamping profiles used for solar power system on south side: www.raico.de • Tüscher Dach AG, Roofing contractor: www.tuescherdach.ch • Wenger Fenster AG, Roof windows on north side: www.wenger-fenster.ch
Battery	The surplus electricity from the solar power system is stored in second-life batteries. These batteries were previously used in electric postal service vehicles. The LifePO4 batteries still have around 80% battery capacity and are therefore suitable for stationary use. The battery in the KREIS-Haus has a storage capacity of 14.4 kWh and is being used in practice for the first time in this form. • Kyburz Switzerland AG: www.kyburz-switzerland.ch
Ventilation, heating, warm water	The ventilation, heating and hot water installations also employ circularity principles. The warm greenhouse air is fed into the living space via a heat exchanger and a comfort ventilation unit. This way, the conservatory and the ventilation take over the function of a heating system. On days when the heat from the conservatory is not sufficient to heat the living unit, the desired temperature in the living room and bathroom can be achieved via the infrared wall heater. The infrared heater features presence detectors, which means that it is only heated when someone is in the room. Since this method of heating is very targeted and thus does not lose any energy through conduction or storage, the energy consumption of the infrared heater is expected to be comparable to that of the heat pump. The hot water is supplied by a mini heat pump, which uses the residual heat from the living space as a heat source. The hot water heating is based on a pre-wall system typically used in bathrooms, but here it is in the facility room of the house. Thanks to the combination of the technologies in the building, the warm greenhouse air can be re-used several times. • Solvair GmbH, Design and planning of ventilation system: www.solvair.ch • Swissframe AG, Domestic hot water heating: www.swissframe.ch • Zehnder Group Schweiz AG, Comfort ventilation unit: www.zehnder-systems.ch • LaminAir AG, Fittings for ventilation system: www.laminair.ch • Schmidlin AG, Raw materials for ventilation. system: www.schmidlinag.ch • MSM Isolierungen AG, Insulation of ventilation pipes: www.msm-isolierungen.ch • Oekoswiss Energy AG, Infrared wall heater: www.oekoswiss.ch
Building automation and electrical installations	All the electrical installations in the KREIS-Haus are connected and controlled from a control centre. The rooms are equipped with sensors for humidity, temperature, CO_2, etc. There is also a weather station on the roof. In the living room, the

	systems can be accessed on a tablet in order to monitor their functionality and to adjust the configuration to the needs of the residents. The data from the technical systems is recorded and can be evaluated by the researchers. • Comtexis AG, Building automation: www.comtexis.com • E. Kunz AG, Electrical installations: www.kunzag.ch

Water and Nutrient Cycles

Water cycle	For the tap water, rainwater is collected from the roof and processed into drinking water via a series of filtration (particle filter, activated carbon, UV-LED). The innovative UV-LED requires much less electricity than conventional UV lamps. Additionally, the UV-LEDs do not contain toxic mercury and have a much longer service life. Thanks to the dry separating toilet, no wastewater is produced from the toilet. The slightly contaminated wastewater from the bathroom and kitchen is treated and reused directly in the house. The water treatment plant is installed in a mobile box and purifies the wastewater based on natural and resource-saving processes. The plant requires minimal maintenance and energy and is based on a low-tech principle. Moreover, no chemical additives or high-tech components are used for the water treatment. The treated water is used for irrigation of the rooftop garden. This pilot technology was developed by the ZHAW and is unique in Switzerland. • Abderhalden Gartenbau AG, Construction wastewater treatment: www.abderhalden.ch • ZHAW Research group Eco-technology, Development of wastewater treatment: www.zhaw.ch/iunr/oekotechnologie • Vuna GmbH, Concept for water cycle, filters for tap water: www.vuna.ch • AquiSense Technologies, UV-LED: www.aquisense.com
Nutrient cycle	Thanks to the separation toilet, which collects urine and faeces separately, nutrients can be recovered from the faeces. The urine is collected in a tank under the house and processed into fertilizer using a prototype urine evaporation module. Furthermore, the urine is stabilized in the tank and is therefore odourless. The faeces are transferred to the room behind the toilet via a conveyor belt, which is operated with a foot pedal. There, it is processed into compost through vermicomposting. Both the compost and urine fertilizers are used in the rooftop garden for plant cultivation. • Vuna GmbH, Concept for nutrient cycle: www.vuna.ch
Vegetable farming in the building	On top of the living space (in the conservatory) vegetables are grown in a plant bed. The soil was sourced from the excavation of the house. The waterproofing of the plant bed is made from synthetic rubber and is free of toxins and pollutants. In the lower part of the conservatory, there is a hydroponic setup where plants can be grown directly in water without the use of soil. This is a space- and resource-saving method for plant cultivation. • Contec AG, Rubber sealing: www.contec.ch