Cradle to Cradle®—Parquet for Generations: Respect Natural Resources and Offers Preservation for the Future

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Abstract Indoor air quality matters in regard of health risks of indoor exposure to particulates. Small particulates indoor are 3–8 times higher than outdoor (Heimlich 2008). The air quality indoor suffers. Industrial products such as building materials, paints, furniture, textiles, flooring, and electronics are off-gazing and in general incorporate toxic ingredients. The environmental and human toxicology quality is a key factor for a healthy living environment. Health risks of indoor exposure to particulates matter in regard to quality of industrial produced products. Wood will certainly stay as one of the leading and the most preferable construction material in the future due to its environmental, local availability, and aesthetic characteristics. Nowadays, using wood in architecture is very fashionable. Research and developments in wood production as well as in wood construction will strongly form the future of sustainable development practically in all parts of the planet Earth. Wood today is trendy, fashionable, and one of the most accessible materials and has an aesthetic view with a natural look and a visual attractiveness, together with the smell, sound, and touch; natural wood is perceived as luxurious. Development could be seen also in façades, inside and other surfaces of modern structures which are increasingly being used. Sustainable luxury products incorporate extraordinary aesthetics, handle, care, function and in addition, to be sustainable need to be safe for humans, society, and the environment. Resources and natural resources are scare and need to be protected in changing the design of the products we use according Cradle to Cradle® principle 'Remaking the way we make things' and 'Towards a circular economy.' For companies, this implies entrepreneurship to tackle the large impact in change of behavior, culture, marketing and business models in closing the loop, and taking the goods back from the user. The case study, Cradle to Cradle® (McDonough and Braungart

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2002)—Parquet for Generations (Bauwerk Parkett 2017)—Respect Resources and Preservation for the Future, illustrates a successful lighthouse example from industry.

Keywords Parquet · Cradle to Cradle · Sustainable development · Living and working environment · Circular economy · Carbon dioxide

1 Introduction

We do not inherit the Earth from our Ancestors; we borrow it from our Children. Unfortunately, world's population have caused huge influence on the environment, exceeding carrying capacity of the planet Earth, and if our nowadays society and existing economy are not transformed drastically, we risk descent into polluted environment and unhealthy urban conditions, depletion of virgin materials as well as loss of precious biodiversity. Our current model of economic and social growth is stimulating this unhealthy system, and, as a consequence, we have already passed the upper limits of our Earth's capability to support us.

It is important that construction wood remains during installation and use period as pure as possible, without any environment unfriendly additives, primers, coatings, impregnations, or mixtures of different bio-products in various composite materials, which are difficult or impossible to separate after use.

Forest-based bio-products, where wood represents its main position, as a source for structure on non-structure material in the building sector are the same as passive sun gain in the environmental friendly consumption economy, the most acceptable and available non-artificial and non-toxic renewable source. Bio-based raw substances are grown by the help of sun insolation in visible and IR radiation spectrum that reaches at our planet, and its surface, in non-constant, variations are drastic for the various positions on the Earth, time of the day/year, weather, and other situations. Helps the photosynthesis development is biological growing by using CO_2 from the air, what resulted that this same quantity of CO_2. This global warming potential gas (in this case CO_2) is kept in bio-based raw material until the discharging with oxidation progression occurs (fire, rotting, bacterial and fungal decays, ingestion by animals). Wood as a bio-product is ideal for storing CO_2, especially in built houses and their bearing or non-bearing constructions, where CO_2 could be stored for longer periods counted in decades if not even centuries. Even more, after ideal closed-loop life cycle chain, bio-based elements could be easily recycled and again settled into life cycle (Kunič 2017).

Health inside environments like rooms, cabinets, offices, hotel rooms, classrooms, and other private and also public spaces is a crucial characteristic of designing proper indoor environments for living and working. Especially because people spend large part of their time inside (Kim et al. 2001; Košir et al. 2010; Gilbert et al. 2008; Kunič 2017). Furthermore, using wood products, especially natural wood, for interior surfaces and interior elements has been manifested to have very positive influence on inhabitants (Jelle 2011; Kutnar and Hill 2014; Pajek and Košir 2017;

Arkar et al. 2018; Gustavsson et al. 2006; Dovjak et al. 2012; Lakrafli et al. 2017; Paganin et al. 2017; Kitek Kuzman and Kutnar 2014).

Working with wood as a natural raw material means accepting an obligation. Natural and bio-based wood is the very precious re-growing, renewable natural substance in practically all regions. Wood is a real and modern building and architectural product, extremely useful for future. Nevertheless, by all added chemicals (glues, adhesives, fillers, protecting and preserving additives, lacquers, etc.), the resource wood becomes after the life cycle a hazardous waste. Bauwerk Parkett, a Swiss-based Company, is opening a new chapter and has adopted and developed a new technology under the name 'Silente,' which follows the sustainable development strictly according to the principle Cradle to Cradle® design. It is valued only for innovations in closed-loop substances' life cycles and guaranteed assurance in such productions that are using chemicals which are safe for humans and the environment. Unlike conventional parquets, Bauwerk Company has planned an innovative way which is suitable for generations. Thus, product will never be, even at the end of life cycle, a waste product, beside that also not to consume environmentally harmful or unnecessary energy. All raw materials, mostly natural ones, and the water resources are always used with intense care. Bauwerk Company strictly works in a fair-minded and ethically correct social responsible manner, in relation to company's workers as well as to clients and other stakeholders. On this innovative path, EPEA Switzerland has independently assisted Bauwerk with the development and execution of the sustainable vision according to Cradle to Cradle® principles. From up to 36 suppliers, all raw materials and ingredients are scientifically assessed on environmental impact, energy use and CO_2 evaluation, water treatment, and reutilization. As a result, Bauwerk Parkett products obtained under the product group name 'Silente' Gold level according to principles Cradle to Cradle certified™ certification program. Even more, all wooden floors that include the new innovative 'Silente' technology are acceptable to be returned to the Bauwerk Company after they are easily dismantled from the user's floor. With new innovation, called 'Silent-Mat', the Bauwerk's wooden floor layer could be separated without being destroyed and could be used up to three times, what means that all ingredients can be either re-conditioned or recycled for new production of final goods. The raw material lifetime will be extended from 25 years of use to 75 years of use. Those unique products consist to man, species, and the environment absolutely non-toxic substances. Thanks to this closed cycle, rather than a linear process as happens by other producers, Bauwerk conserves the valuable resource wood and acts in the interest of future generations, such as:

- defined processes of health and non-toxic raw substances and chemicals,
- consumption of all subsequent raw materials in closed life cycle,
- the evaluation of use of proper energy and CO_2 supervision,
- environmentally friendly water treatment,
- society responsibility and social fairness.

Wood is the most essential re-growing and renewable non-artificial raw material in practically all regions and is assumed to be the building material with an exceptionally bright future. Unfortunately, with hazardous chemical substances,

adhesives, lacquers, the wood raw material becomes, if not before, surely after the finished life cycle, a hazardous waste.

Sustainable development under principle Cradle to Cradle® design deals with the new perspectives of a production site culture with all procedures of fabrication, use, and after use periods which are planned by transference of ethics of Nature. Thus from Cradle to Cradle®, where Nature knows material flows, unlike as by human behavior, Nature produce no waste at all (every part is totally recycled, without any waste). Nature is very effectively and cleverly implementing the right raw substances at the accepted time and on the suitable place. In the case of implementing chemicals against rotting, fire and other general resistance, innovative design should be designed with such chemicals, which are naturally acceptable and safe for bio-natural whole life periods.

2 Sustainable Development According to Cradle to Cradle® Design

The innovative idea of sustainable development according to Cradle to Cradle® design develops and defines recyclables and quality of goods. Together with all respect to difference with the existing down-cycling system, the environmental condition of the used substances stays during numerous life cycles of certain product, where only pure and safe chemicals could be used.

The goods are designed with respect to the environmental friendly system to sustain the condition of strictly all natural substances during numerous use periods, taking into account all the manufacturing procedures as well as the reutilization process. To be precise: no waste at all under all ingredients are considered only as nutrients. The right materials are integrated in defined cycles (metabolism) at the right time and place (Braungart 1992; Hawken and Lovins 1999; Gilding 2011; McDonough 1993).

The three Cradle to Cradle® design principles of sustainable development are (McDonough and Braungart 2002):

- Waste equals food,
- The energy use is only allowed in the form of renewable energy (only renewable resources),
- Diversity is allowed and is even encouraged.

Nature as a unartificial model uses sustainable developments as a principle in Cradle to Cradle® product. Sustainable developments according to innovative process in Cradle to Cradle® products reflect a new security level and differentiate model (Fig. 1).

Consumer products such as natural textiles, cosmetics, cleaning substances, detergents are planned so with care that they can be infinitely passing the biological cycle in principle to forever. The recycle to organic nutrients and promotion of biological

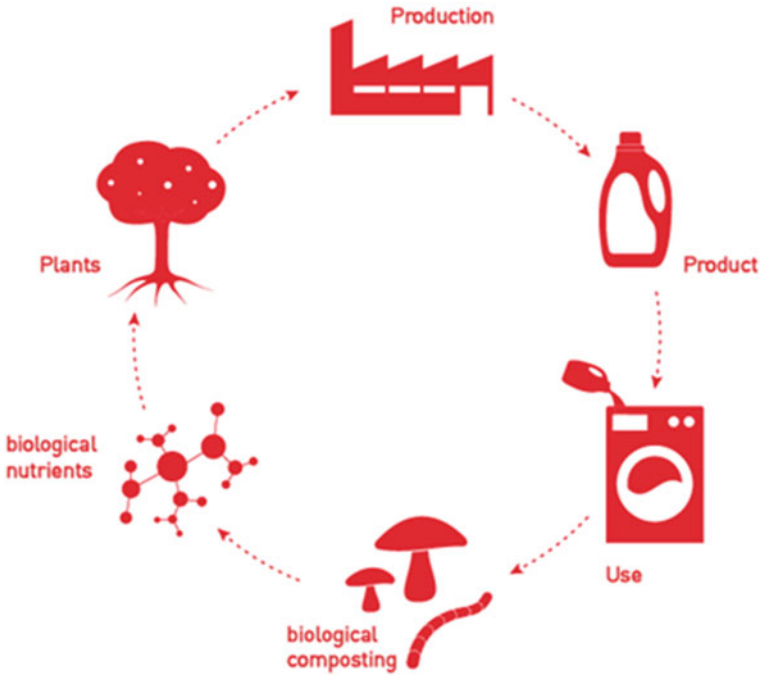

Fig. 1 Biological life cycle: organic nutrients in biological metabolism. *Source* Cradle to Cradle®

nutrients in biological life cycle, identically as in nature such as plants, are growing. The renewable raw substances are used for new products (Fig. 2).

Service Products such as TV sets, home appliances, cars, synthetic fibers, textile, etc., in other words so-called technical nutrients, are after the life cycles separated with a goal to allow the manufacture of new products or goods after finishing their original purpose. The materials after the life cycle period belonged to the manufacturer, which preserves them through well-organized system into the beginning of new technical life cycle (technical metabolism).

2.1 Differentiation Represents Quality Equal Quantity

Sustainable development under system Cradle to Cradle® design transfers to industrial systems the code 'Quality equal Quantity.' All flows of substances are planned with the goal to be valuable and suitable for the reuse and saving processes of biological and as well as technical metabolism. This methodology liberates in all views and slows down or totally reduces all harmful influences on the environment.

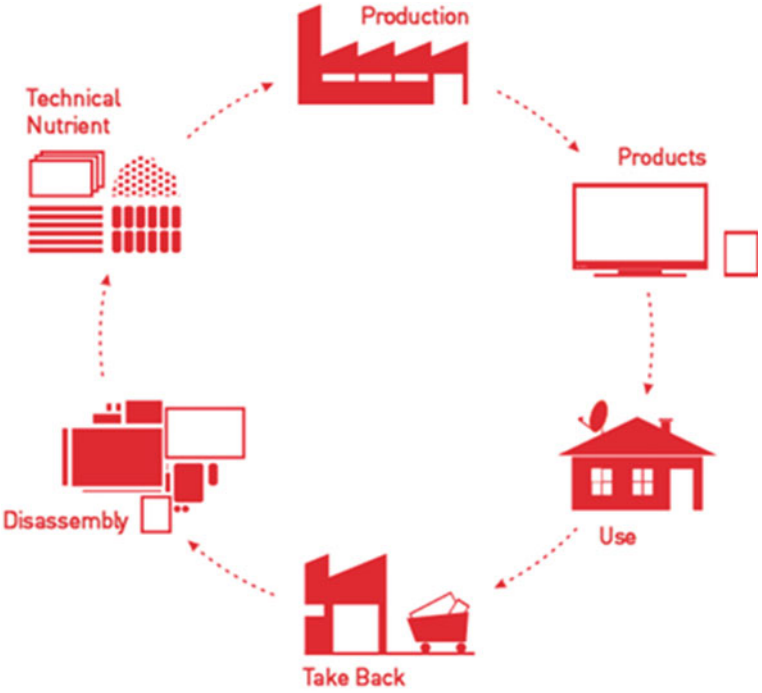

Fig. 2 Technical life cycle: technical nutrients in technical metabolism. *Source* Cradle to Cradle®

2.2 Total Beauty Design

Professor Michael Braungart defined sustainable product performance and sustainable development according to Cradle to Cradle® design as "total beauty design" (Cradle to Cradle 2017). Beauty in this case is not only based on aesthetics, but it goes beyond sustainability, beyond industrial design and beyond form follows function. "Total beauty design" incorporates a new dimension of product quality which is perceived as luxury.

3 Redefining Product Quality

International standards which are covering environmental influence of construction activities, buildings, and period of use are numerous (EN 15804 2012; ISO 14025 2009; ISO 14040 2006; ISO 14067 2013, to mention only few of them). Quality of the products, with customer service, proper customer communication, consistency in respecting its core values, and positive interactions with clients, has allowed many companies to build and hold a unique market position for the certain company and for

Fig. 3 Cradle to Cradle logo. *Source* Cradle to Cradle®

specific business or industrial sector itself. Industrial (technical) or biological goods can be specifically designed or even redesigned to retain its high quality for multiple uses. After the end of life cycle, products could be transferred into high-quality biological or technical nutrients to serve as a high-quality 'raw materials' input for next biological or technical cycle. All materials used by Bauwerk product's life cycle meet the highest standards. For retaining such a high-quality level, products are frequently tested by accredited independent laboratories in more countries. Bauwerk Company is constantly researching to increase its technical quality, in the direction of healthier indoor environment, ecological fairness, and social quality.

4 Certification Program: Cradle to Cradle Certified™

The Cradle to Cradle products Innovation Institute (Cradle to Cradle 2017) is a non-profit organization, administers the sustainable development, and supervises certification process with Cradle to Cradle Certified Product Standard. This organization was specially established to create a new drastic change in production that rearranges the manufacturing and producing of goods into an encouraging strength for environment, public, humans, economy, and the Earth (Fig. 3).

The quality improvements are infinitive and developed the non-profit company by architect William McDonough and Professor Dr. Michael Braungart after more than 25 years of experience of research and growth. The Institute with headquarter in Oakland, California, USA, is directed by a self-governing board of managers. Foundations and individuals who share common values for care of the environment and hope for the future supported non-profit and thus independent Institute's work.

Initial financial funding has been done by the Nationale Postcode Loterij and the Schmidt Family Foundation, founded by Wendy and Eric Schmidt. Remaining self-sustaining revenues will result from certification, licensing fees, and specific training programs (Cradle to Cradle 2017) (Table 1).

Based on the revolutionary book 'Cradle to Cradle: Remaking the Way We Make Things' by William McDonough and Michael Braungart (2002), the Cradle to Cradle

Table 1 ABC—*X* categorization.

IDENTIFYING THE BEST MATERIALS:
ABC-X CATEGORISATION

Goal: Best quality of raw materials, chemicals and ingredients

Category	Description
A	The material is ideal from a Cradle to Cradle perspective for the product in question.
B	The material supports largely Cradle to Cradle objectives for the product.
C	Moderately problematic properties of the material in terms of quality from a Cradle to Cradle perspective are traced back to the ingredient. The material is still acceptable for use.
X	Highly problematic properties of the material in terms of quality from a Cradle to Cradle perspective are traced back to the ingredient. The optimization of the product requires phasing out this ingredient or material.
GREY	This material cannot be fully assessed due to either lack of complete ingredient formulation, or lack of toxicological information for one or more ingredients.
Banned	BANNED FOR USE IN CERTIFIED PRODUCTS This material contains one or more substances from the Banned list and cannot be used in a certified product.

Source Cradle to Cradle®

Certified Product Standard leads inventors, researchers, developers, and producers through a repetitive development procedure (step by step), from the bottom (BASIC level) to the top (PLATINUM level). Cradle to Cradle Certified™ is a product certification, a quality brand and not an eco-label, as it covers all products in all industries within one certification scheme and is not based on limit values for chemicals; however, it is designed to include positively defined ingredients.

Quality is by classification defined into five criteria categories and one recommendation:

- Material Health—MH in short (stage 5.0),
- Material Reutilization—MR (stage 6.0),
- Renewable Energy and Carbon Management—RE&CM (stage 7.0),
- Water Stewardship—WS (stage 8.0),
- Social Fairness—SF (stage 9.0), and
- Recommendations for Product Optimization—RPO (stage 10.0).

5 Material Health

According to Cradle to Cradle, principles are goods with raw materials and all ingredients are assessed through the whole delivery process and precisely weighed for influence on man, animals, and the whole environment. The criteria at each level build towards the expectation of excluding all toxic and unidentified chemicals and becoming nutrients for a safe, environmental friendly continuous cycle.

5.1 Healthy and Safe Materials

The assessment of Material Health generates material substances review ratings evaluation based on the hazards of substances in products and their relative routes of exposure during the intended, and highly likely unintended, use and end-of-use product phases. All ingredients above 100 parts per million (>100 ppm or >0.01%) in a product need to be precisely and critically scientifically assessed according to the Material Health principles. The crucial aim for all goods is manufacturing processes which are only using those substances that are improved and are not prohibited as X or gray evaluated substances.

Naturally, substances are able to reach gradually greater ranks on accreditation level as the parts of substances are improved and environmental friendly raw and recycled materials in the finished product increase.

5.2 Testing Volatile Organic Compound (VOC) Emissions and Results

The goods which are intended for inside use, or influence on living or working inside air pollution, should be strictly in compliance according to the Cradle to Cradle Certified™ VOC emissions prescriptions that are essential for all applications to the Gold and Platinum level of certification and for Externally Managed Components (EMCs) at all accreditation stages. The purpose of this obligation is to guarantee that VOCs are not released from goods that influence the content of VOCs in the inside living or working space, what was confirmed by excellent testing results:

- Volatile Organic Compounds (VOCs) that are checked to be carcinogenic, endocrine disruptors, mutagenic, reproductive toxins, or teratogenic should be below detection limits (i.e., less than 9.0 $\mu g/m^3$ for formaldehyde and less than 2.0 $\mu g/m^3$ for all other chemicals compounds).
- Total Volatile Organic Compounds (TVOCs) must be less than 0.50 mg/m^3.
- Individual VOCs would receive an *x* assessment criterion, but total contents must be below 0.001 *x* [TLV/MAK] in any case.
- The period of measurements takes place for at least of 7 days.
- The analytical laboratory that tested and measured values must be ISO 17025 accredited.

6 Material Reutilization

Eliminating the concept of ‘waste’ is an important goal of sustainable development according to Cradle to Cradle® development concept as a material design exclusively to encourage the conception of an adjusted life cycles of ingredients that totally

remove the model of 'waste', just opposite as in the conventional products. The intention is to create encouragements for producers to remove the above-mentioned model of 'waste' by planning innovative goods with substances that may be infinitively cycled. This program encourages producers to be more responsible for proper designing of production systems. Naturally, to achieve a goal in certification process, the all necessities at all lower scores are to be met as well. The further text described the definitions of recommended procedures for new design, research, and development.

6.1 Material Reutilization Score

Standard Requirement according to Cradle to Cradle® principles regulates the next Material Reutilization Score that is obligatory for certain assessment:

- BASIC level: any substance in the material must be declared to fall in a biological or technical cycle.
- BRONZE level: a good has whole life cycle a Material Reutilization Score higher or equal to 35%.
- SILVER level: the good gets whole Material Reutilization Score higher or equal to 50%.
- GOLD level: the good gets a Material Reutilization Score that is higher or equal to 65%. The producer has accomplished a suitable methodology for the material.
- PLATINUM level: the good gets a Material Reutilization Score of exactly 100%. The good's substances are sourced from totally re-covered substances after the use period and reused.

7 Renewable Energy and Carbon Management

Each certification step leads in the direction of carbon-neutral influence and encouraging all activities with total (100%) renewable energy content.

Eco-effective energy production according to Cradle to Cradle® principles follows direction in which production processes in industries and market positively influence the energy supply, ecosystem balance, environment and society. The Renewable Energy and Carbon Management certification level is a mixture of both essential values of sustainable design and development under Cradle to Cradle® system: to generate and use friendly sourced energy and at the same time totally remove the conception of waste.

Renewable energy relocates energy generated from fossil fuels as a consequence is emittance of carbon. Changing the quantity and as well the quality of energy used, influence the balance of CO_2 level in the air and ultimately the climate. Preferably, all emittance could be removed, and energetically needs are generated in surplus to

be delivered for nearby society's needs. In the case emissions arise, they are managed as biological nutrients (i.e., without harmful influence to environment).

- BASIC level: producer follows strict quantification of annual electricity use and greenhouse gas emissions, which are associated with the finishing manufacturing production.
- BRONZE level: a sustainable electricity use plan and CO_2 accounting policy are established.
- SILVER level: at end of production level of the goods, minimum 5% of energy have renewable resources or offset with renewable electricity developments, and more than 5% of all GHG emissions are compensated.
- GOLD level: till the end of production of the goods, at least 50% of energy is suitable origin or compensated with electricity developments, and more than 50% of GHG emissions are compensated.
- PLATINUM level: for whole production of the goods, exactly 100% of energy is suitable origin or 100% compensated with suitable electricity developments, and exactly 100% of GHG emittance is compensated. The gray energy related with the production from Cradle to Gate is categorized and measured, besides that is developed a strategy for optimization. At reuse, development on the optimally prepared plan is applicate. More than 5% of the gray electricity connected with the production according to Cradle to Gate principles are balanced by compensation or other sources (e.g., product redesign, proper contractors, reserves in the use stage).

8 Water Stewardship

Those methods are planned to respect water as a valuable and irreplaceable natural reserve for all living beings on our planet. With respect on all levels, that developments are necessary in view of cleaning up effluent, even to drinking water criteria.

8.1 Treating Clean Water as a Valuable Resource and Connection with Fundamental Human Right

Water stewardship generates responsiveness and leads to the water management as an irreplaceable good by stimulating operative controlling and usage policies. Each of the production facility has a significant obligation to maintain this for living nature vital reserve, i.e., water.

- BASIC level: the producer has not reached any destruction of water pollution during 2 years. Water-linked problems are considered; e.g., the producer regulates if shortage is a problem, and subtle environment and ecology environments are at danger due to straight procedures. Water stewardship program cares that

achievement is reached, with demonstrations of re-application, and significant development on action procedures.
- BRONZE level: water audit is finalized on a production site.
- SILVER level: (i) chemicals as a result of production processes in water effluent are detected and evaluated, or, (ii) supply connected to water subjects (a suitable influence plan is established).
- GOLD level: (i) optimization of all chemicals in effluents, which are related to production processes (chemicals recognized as problematic….), or, (ii) Silver-level requirements requested a development on the strategy, what is demonstrated (production sites with no problematic effluents).
- PLATINUM level: drinking water quality standards are strictly required for all water leaving the manufacturing productions.

9 Social Fairness

All activities inside companies are planned to protect all humans and environment in such a way that development could be established and positive influence on the humankind and the environment is ensured.

9.1 Positive Support for Social Systems

Social Fairness stage in certification assessment confirms that development is reached in direction to sustainable operations that bring to all owners an interest, also to employees, society participants, customers, and the environment. For business, ethics is necessary to overcome the boundaries of the existing company habits.

- BASIC level: an inside operation audit is made to confirm existence of basic human rights. Organization processes confirm those topics that are established. For re-application is required a demonstration of progress on the management plan.
- BRONZE level: a self-audit of full social responsibility is completed; besides, positive impact strategies, which established on documents ‘UN Global Compact Tool’ or ‘B-Corp.’, are developed.
- SILVER level: one of the next issues is closed: (i) raw substances content to a minimum of 25% of the raw substances by weight is finished successfully, or, (ii) fully investigated supply side connected to minimal social requirements, and a suitable influence plan is developed, or, (iii) the producer is guiding an active advanced society program which stimulatingly influences employees’ lives, the local community, global community.
- GOLD level: two requirements of the Silver score are finished.

- PLATINUM level: a third party completed production site audit according to a worldwide accepted social responsibility platform, as 'SA8000 standard' or 'B-Corp'; besides, all Silver-level prescriptions are finished.

10 The Case Study Bauwerk's 'Silente' Parquet

Operating, manufacturing, or assembling activities with wood means taking care and responsibility of Nature and environment. Wood is one of the most important re-growing natural raw substance in practically all regions and is assumed to be the building substance of the future. Illegal deforestation and depletion reduce this issue for forthcoming generations. For the wood productions, it is essential to take responsibility for sustainable forestry and wood supply, which is fundamental and vital from an ecological standpoint. This is necessary and important for ecology, environment, and whole Nature. Exclusive wood supply from ecological forestry was always operation standard for Bauwerk Company. Furthermore, Bauwerk Company always confirmed to use of advanced solvent-free adhesives and lacquers, implementing the extensive system of recycling in the production procedures; the last innovative techniques are used to lower dangerous emissions and high employees and the environment safety prescriptions, all according to ISO 14001 standards.

The strict execution of guidelines by supplying natural wood materials and final marketable goods is a significant producer's methodology. For all Bauwerk wood products as well as parquet products, wood raw materials are sourced from sustainable forestry.

By adapting a design and a new innovation under the name of "Silente", Bauwerk is breaking new ground. Silente products follow the sustainable development under the principle of Cradle to Cradle® design, which means a closed raw material cycle and a respective quality assurance production process.

10.1 Bauwerk Parkett AG Company Profile

Bauwerk Parkett is a Swiss company with a long-standing tradition and combines reliability and precision in the manufacture of top-quality parquet and other wooden floors. Proud of its origins, the company constantly strives toward innovation. In the last few years, Bauwerk has seen significant development and has set out on a new course, converting from a technological and production-oriented enterprise to a market-oriented company with a focus on healthy living, sustainability, and design.

Over two-thirds of Bauwerk products are manufactured in St. Margrethen (Switzerland). Bauwerk Parkett AG has two further factories in Kietaviskes (Lithuania; since 2014) and Đurđevac (Croatia; since 2017). Bauwerk's product portfolio comprises 350 articles, ranging from two-layers to three-layer as well as solid parquet. Bauwerk sold approximately 4.1 million square meters of parquet in 2016.

10.2 Parquet for Generations

Bauwerk Parkett (2017) is designed in such an innovative way that substances constantly stayed in closed loop life cycle and no part of the product ever changed into waste material or final product need excessive non-renewable energy. Those substances in product stayed in product life cycle even for more centuries; all needed water inputs are preserved and cared; and company behaves in a fair and socially responsible manner in relation to its employees as well as to the public and society. On this successful way, accreditation assistance from EPEA Switzerland company is helping Bauwerk in application of the Cradle to Cradle® program, its sustainable design and development of products, and as general assessor supporting for its goal to reach the Cradle to Cradle Certified™ successful authorization.

All ingredients, wood and other input substances supplied by 36 delivering companies, are carefully checked with Material Health certification steps, Material Reutilization score value, impact on environment and checked in whole life cycle loop into reusable substance original state. Bauwerk's manufacturing facilities as well as all suppliers were subjected to close scrutiny during the new 'Silente' technology certification process.

The parquets and other wooden floors that include the innovative 'Silente' know-how could simply be taken up without any effort (thanks to the new 'Silent-Mat' innovative solution), and what is very important is it could be anytime returned to the company. Naturally, all returned components are either recycled or re-conditioned for new quality products. Because of this infinitive close cycle, Bauwerk conserves the valuable wood resources and acts in the interest of environment and future generations. The products that include the 'Silente' innovative know-how are produced completely from substances that are harmless for both the environment as well as for humans.

10.3 Innovative Story of 'Silente' Products Was Awarded with Gold Certification Level

Bauwerk Parkett Company is always fastened with glue totally to the below surface of construction, which guarantees the improvement that a perfect connection is secured to the below surface, for ideal insulation against transmission of impact noise. Besides that is very important that skilled workers are trained in practical and theoretical level to assure an ideal assembling of the wooden floor product.

The sustainable design and continuous development were confirmed by Cradle to Cradle Certified™ Gold-level prize for Bauwerk's 'Silente' wooden floor elements, because:

- the strict consumption of health and thus non-hazard substances,
- the all raw and recycled substances are always a need,

- the valuation of environmental friendly energy sources and maintenance of carbon management,
- environmentally compatible water management and water stewardship program,
- social responsibility to workers and society,
- Bauwerk Parkett is ISO 14001 certified.

10.4 Circular Economy—Task, Innovation, and Implementation

Process of the disassembling of an attached conventional wooden or parquet floor is hard and not friendly activity; besides that the removal work loud, unclean, and exhausting, it also takes a lot of time- and patience-consuming and thus costly. Additionally, the wooden floor is destroyed during removal and must be discarded. Because of the different material components, reuse of the such waste is impossible.

It is more and more important from professional as well as from user site to find an efficient innovation connected with insulation against walking and impact sound noise. These needs followed by starting a new program in 2011, when Bauwerk Company with helpful support of the German manufacturer company WPT designed and developed an innovative walking and impact noise insulating mat. The goal was to reach strong innovative know-how, high technical acceptance, and ideal environment friendliness. The solution as a result of mutual research between both companies was finished by use of 80% content of environmental friendly substances (chalk and polyurethane glue), positioned just below and above the mat, with a function similar to existing solutions. This new and innovative mat together with the application method is named as 'Silent-Mat,' was patented by producer, and is exclusively made only for Bauwerk Parkett company in manufacturing format as 7.5 m × 1.0 m in rolls. The montage starts by gluing of innovative mat on the floor surface, followed by direct gluing of every Bauwerk Parkett or other wooden floor product.

During time and experience with new innovations was a new solution of wooden floor product for material health, their use, recovering and reuse was developed, by maintaining its high value over its entire lifetime and multiple lifecycles. The idea which came up was to develop the parquet floor nondestructively, so the wooden floor can be used repeatedly in a closed loop and multiple product cycles. Even more, those new know-how solutions are successfully combined into one solution; by direct montage in the factory of new innovative mat rolls on the bottom side on finished surface of parquet, and later on the construction site of the floor.

EPEA Switzerland (2017) is supporting and supervising productions with various products and activities in different sustainable research and development process for application of Cradle to Cradle® certification, which is run with an experienced with plenty of practice cases, educated, and multidisciplinary functioning team. In the Alpine region, parts of Cradle to Cradle® assessors are implemented in all productions. Chemical reviews on scientific level and other chemical evaluations

for all certification developments are generated in tight collaboration with EPEA Internationale Umweltforschung GmbH, Hamburg, Germany.

Parquet Cleverpark is available in the dimensions 1250 mm × 100 mm. The wooden floor system was successfully tested for impact sound insulation at the EMPA institute in Dübendorf, Switzerland.

Around 1,500 m^2, 'Cleverpark Silente' has been applicated for a major project in Chur, Switzerland, what was at the beginning major 'Silente' applied new innovative wooden floor area and thus presented the testing surface in view of effective acoustical insulation properties. All this was reached with use of innovative solution 'Cleverpark Silente,' and the relation to the results obtained in laboratory and values in the certificates was confirmed. The scientific institute EPEA Switzerland assessed in 2013 the Silver certification level according to Cradle to Cradle Certified™, and the chemical optimization was done in 2015 for Gold level.

The Bauwerk Company and their products have been evaluated in five main certification criteria and one recommendation:

- Material Health—MH,
- Material Reutilization—MR,
- Renewable Energy and Carbon Management—RE&CM,
- Water Stewardship—WS,
- Social Fairness—SF, and
- Recommendations for Product Optimization—RPO.

11 Luxury

Sustainable products practically share the same values of qualities and other criteria of luxury goods. Sustainable luxury products inherit extraordinary creativity and design, outstanding materials with good quality, and properties such as durability. The context «less but better» shares the spirit of sustainable luxury. Luxury goods should have implicit sustainability built in; they are long-life products and consequently do not go out of fashion.

Sustainable luxury products offer the consumer fulfillment of all their individual values and desires by introducing material healthier consumer choices rather than making them feel guilty.

Luxury products have not been promoted as sustainable. The «green» touch was not desired, but today products with «invisible 2 beauty» in design with the right materials and chemicals used are recognized from consumers. Leading brands are taking steps in this trend and are presenting sustainable luxury as an essential part of their own brand image. In addition, social and environmental awarenesses are increasing and global resources come under investigations; this is creating a new environment for the luxury industry.

Bauwerk created a clear pronounced marketing message to the consumer (Bauwerk Parkett 2017).

Why is this so important? We are spending during living or working periods from minimum 80 up to 90 or even longer part of our live periods inside space, needing daily from 10 to 20 m^3 of fresh air. Beside that airtight building walls, roofs, and windows, what represent building envelope, make sense in terms of energy, ventilation, so, to reduce harmful substances. Appropriate construction and finishing elements are an unconditional need for reaching a guarantee for non-sick inside air. Bauwerk Company has been testing quality and environmental friendliness of their products since year 2010 together with the Sentinel Haus Institute.

Is parquet healthy? No. Even though wooden substances in construction products are a precious bio-based and environmental friendly product, the producers of wooden floors implement additional sticking substances, protecting layers, and different finishing. The highest standards and regular testing procedures are essential for all materials used by Bauwerk Company independently of the local country production.

11.1 Innovative Sound Reduction

Our ears perceive intrusive sounds or fast changes in sound levels as noise. Glued parquet substantially reduces footfall sounds. Bauwerk's 'Silente' technology is an innovative system solution that reduces footfall and impact sounds even further, an effect that is particularly sought-after in renovation projects.

11.2 Invisible but Measurable

High environmental and material health standards in closed living or working rooms are not successfully developed by coincidence; proper design, well-oriented project, labor checking, and increasing technical and environmental values. Separately from environmental friendly inside room air and proper room acoustics, Bauwerk's 'Silente' innovative wooden floor solution solved important strong positive arguments: absence of electrical static charge; it feels much warmer than any other floor surface, also visual, and beside that natural wood surface, it is temperature-friendly in summer (enough cool) as well as in winter (friendly warm).

Odors in buildings, especially those that occupants perceive as disturbing, may have many different sources; among them are building materials such as paints, varnishes, wooden materials, glues and insulation materials used during the construction or renovation of buildings. Fixtures and fittings, for instance, furniture or office equipment, affect the emergence of odors. Bauwerk Parkett has no smell, and rooms can be used immediately after its installation.

Table 2 Respective threshold values are substantially lower than those required

Parameter	DIBt/AgBB2015[a]	Eco-Institute label
TVOC after 3 days	10.0 mg/m^3	3.0 mg/m^3 (=3000.0 µg/m^3)
TVOC after 28 days	1.0 mg/m^3	0.30 mg/m^3 (=300.0 µg/m^3)
Formaldehyde	0.120 mg/m^3	0.0360 mg/m^3 (=36.0 µg/m^3)
After 28 days	0.120 mg/m^3	0.0360 mg/m^3 (=36.0 µg/m^3)
Ammonia	0.10 mg/m^3 (=149.0 µg/m^3)	100.0 µg/m^3
Individual substances—reference values for interior environment	No	Yes
Material test	No	Yes
Odor test	No	Yes
Phthalate softening agents	Generally allowed	Generally prohibited
Halogen compounds	No specific requirements	Generally prohibited

Source Bauwerk
[a]Switzerland is following the European standards

Bauwerk Parkett flooring has been tested by independent, qualified institutes to determine its health properties and has successfully passed the strict Eco-Institute criteria, including those applying to building assessments by the Sentinel Haus Institute, DGNB, or Leed. The respective threshold values are substantially lower and more extensive than those required for general building authority approval or quality labels for other floor coverings, as can be seen in the Table 2.

11.3 Healthy Living—Invisible but Measurable

We intensively care for humans as well as for whole Nature, because we do not inherit the Earth from our Ancestors; we borrow it from our Children.

Everybody who works with natural bio-based materials has a tender intuitive relation for natural origin of certain product and has special relation to environment, energy use, and whole life cycle loop. That is why Bauwerk Parkett Company develops continuous relationship to healthy living and working inside room environment, what is included in the next properties:

- the special, fashionable wood and other raw substances, totally recyclable and are produced exclusively in environmental friendly way,
- to avoid all toxic or other environmental unfriendly substances in whole tightly closed life cycle loop, i.e., all wooden substances, with proper production, to product and to living or working indoor environment,
- open and fair partnerships with final users, customers, dealers, montage groups, all suppliers, and their numerous subcontractors,

- to be responsible and very reliable partner to whom you can rely on,
- to manufacture exclusively market leading wooden surfaces in quality and environment-friendly aspects, acoustically pleasant, reliable and environmental and to nature acceptable way.

12 Silente Technology

'Innovation and Leadership are the only survival strategies' emphasized Kälin (2017) of EPEA Switzerland and longtime expert on environment, certification, and textile. The management of Bauwerk Parkett AG created with a visionary mindset, profound management skills, and courageous decisions to generate a recognized lighthouse position of a company implementing sustainable development with the Cradle to Cradle® design with a holistic approach throughout the company, as:

- visionary mindset to create a solution to safe resources for coming generations,
- moral imagination 'transforming nature' (Gorman 1998),
- redesign of adhesive system for entire company,
- implementing innovation and knowledge management strategies,
- integrating 'closed loop concepts' into business,
- changing of the business model in taking goods back,
- product responsibility for coming generations,
- product lifetime extension for three generations from 25 to 75 years,
- marketing approach 'healthy living,'
- integration into the entire supply chain, customers, consumers and take back concepts.

Bauwerk's 'Silente' technology is an innovative system solution that reduces footfall and impact sounds even further, an effect that is particularly sought-after in renovation projects. 'Symbiosis between man and nature' described all operations within responsible economy. People who work with wood as a raw input material develop through production process a special feeling and relation to our Nature, everything related on the 'old but innovative' theory of a symbiosis between humankind and Nature (Fig. 4).

As a result, the system called 'Cleverpark Silente' gets for the topic of Material Health Silver level and in the next four topics: Material Reutilization, Renewable Energy and Carbon Management, Water Stewardship, Social Fairness the Gold level, everything according to principles of Cradle to Cradle Certified™. The assessment covered all materials and their chemical substances above 100 parts per million level in regard to their environmental and health relevance criteria, such as; mutagenicity, reproductive toxicity, carcinogenicity, teratogenicity, endocrine disrupting activity, biodegradability/persistence, toxic poisonousness, substances with possibility of irritating of skin surfaces or eyes, and aquatic harmfulness. The raw substances for the parquet floor are precisely tested for the allowed level of toxic substances and the level of organ halogens (bromine, chlorine and fluorine). The cost of the whole designing

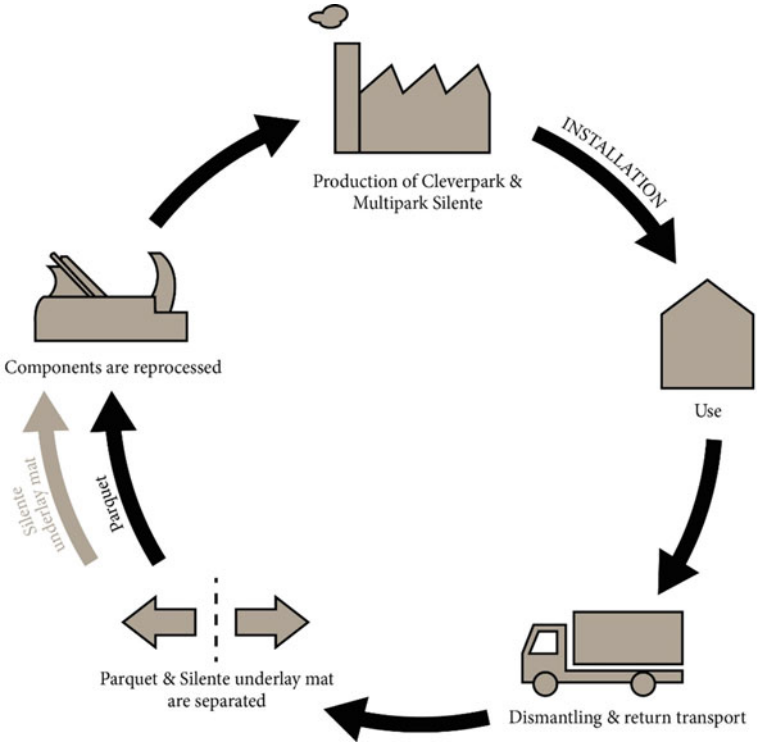

Fig. 4 So-called 'closed loop' is the principle of 'Silente' technology for wooden floors. *Source* Bauwerk

and developing primary group of five employees and additionally external consulting team was high. All chemical components and raw materials were evaluated at EPEA International Umweltforschung in Hamburg.

The certificate level Silver for five issues for Parquet has been awarded in October 2013, whereas in January 2015, the new higher Gold-level project Cradle to Cradle Certified™ has been started. Furthermore, the suppliers were requested for upgrade certification and thus replaced the 'Gold-critical' materials due to optimization process, because a criteria Material Health reached higher Silver level and in the rest of four other chapters reached the Gold status.

Without an active collaboration, this could not be achieved and consequently Bauwerk's assortments 'Clever Park Silente' and 'Multi-Park Silente' have been since June 2015 for the sustainable development confirmed with Cradle to Cradle Certified™ Gold-level certificate, which is unique and the only producer with healthy living wood parquet. All achievements, generated knowledge, and results from the above-mentioned C2C® project was successfully brought in entire Bauwerk Swiss Parquet productions, so now the all Bauwerk Parkett production in Switzerland are according to Cradle to Cradle Certified™ standards at Gold or Bronze.

Fig. 5 'Silente parquet'. *Source* Bauwerk

Bauwerk Company with its products is committed to have finished a tremendous and important step in direction to sustainable environment. The goal in the near future is to use less valuable timber for the same requirements. An important contribution to sustainability is made through the multiple uses of the products.

13 Conclusions

The sustainable development according to Cradle to Cradle® (2017) program increases the profitability in the whole life cycle closed loop of a certain material. All problems in the delivery or supply, the industrial processes and implementation, accomplish much better position. The economy itself, the eco-related indirect costs, and the social parts are thus much more expectable and become profitable.

All needed ingredients and raw materials through the whole supply process are actuality during the process of sustainable development considered from the beginning as the raw wooden substances to final materials in the concept Cradle to Cradle® design. Therefore, the above-mentioned resulted into products of incomparable quality. Finally, an infinitive use of material substances is now accomplished without any limitations (Fig. 5).

References

Arkar, C., Domjan, S., & Medved, S. (2018). Lightweight composite timber façade wall with improved thermal response. *Sustainable Cities and Society*. https://doi.org/10.1016/j.scs.2018.01.011.

Bauwerk Parkett (2017). Healthy living brochure. Retrieved in Nov 15, 2017 from http://www.bauwerk-parkett.com/de.html.

Braungart, M. (1992). An intelligent product system to replace waste management Braungart, Engelfried. *Fresnius Envir Bull, 1*, 613–619. Basel, Switzerland: Birkhauser Verlag. 1018-4619/92/090613-07S1.50-0.20/0.

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Dovjak, M., Shukuya, M., & Krainer, A. (2012). Exergy analysis of conventional and low exergy systems for heating and cooling of near zero energy buildings. *Journal of Mechanical Engineering, 58*(7/8), 453–461.

EN 15804 (2012). Sustainability of construction works—Environment product declarations—Core rules for the product category of construction products, European Standard. European Committee for Standardisation.

Gilbert, N. L., Guay, M., Gauvin, D., Dietz, R. N., Chan, C. C., & Levesque, B. (2008). Air change rate and concentration of formaldehyde in residential indoor air. *Atmospheric Environment, 42*(10), 2424–2428.

Gilding, P. (2011). *The great disruption* (p. 16). New York: Bloomsbury Press.

Gorman, M. (1998). *Transforming nature. Ethics, invention and discovery*. ISBN 0-7923-8120-3.

Gustavsson, L., Pingoud, K., Sathre, R. (2006). Carbon dioxide balance of wood substitution: Comparing concrete- and wood-framed buildings, Springer, Greenhouse gas balances in building construction: Wood versus concrete from life-cycle and forest land-use perspectives, Environmental and Energy Systems Studies, Lund University, Lund Institute of Technology, Lund, Sweden, Energy Policy.

Hawken, P., Lovins, L. H. (1999). *Natural capitalism, creating the next industrial revolution*. Little, Brown and Company. ISBN 0-316-35316-7.

Heimlich J. E. (2008). Formaldehyde. The invisible environment fact sheet series. Retrieved on Nov 15, 2017 from http://ohioline.osu.edu/cd-fact/pdf/0198.pdf.

ISO 14025 (2009). Environmental labels and declarations—Type III environmental declarations—Principles and procedures, standard. Geneva, Switzerland: International Standards Organisation.

ISO 14040 (2006). Environmental management—Life cycle assessment—Requirements and guidelines, standard. Geneva, Switzerland: International Standards Organization.

ISO 14067 (2013). Carbon footprints of products, standard. Geneva, Switzerland: International Standards Organization.

Jelle, B. P. (2011). Traditional, state-of-the-art and future thermal building insulation materials and solutions—Prosperities, requirements and possibilities. *Energy and Building, Elsevier,*. https://doi.org/10.1016/j.enbuild.2011.05.015.

Kälin, A. (2017). Interview with Albin Kälin. Oct 10, 2017.

Kim, C. W., Song, J. S., Ahu, Y. S., Park, S. H., Park, J. W., Noh, J. H., et al. (2001). Occupational asthma due to formaldehyde. *Yonsei Medical Journal, 42*(4), 440–445.

Kitek Kuzman, M., Kutnar, A. (2014). Contemporary Slovenian timber architecture for sustainbility, green energy and technology. Switzerland: Springer. ISSN 1865-3529.

Košir, M., Krainer, A., Dovjak, M., Perdan, R., & Kristl, Ž. (2010). Alternative to conventional heating and cooling systems in public buildings. *Journal of Mechanical Engineering, 56*(9), 575–583.

Kunič, R. (2017). Carbon footprint of thermal insulation materials in building envelopes. *Energy Efficiency.* https://doi.org/10.1007/s12053-017-9536-1.
Kutnar, A., Hill, C. (2014). Assessment of carbon footprinting in the wood industry. In: S. S. Muthu (Ed.), *Assessment of carbon footprint in different industrial sectors*, vol 2 (Eco-Production). Singapore [etc.], pp. 135–172. Berlin: Springer.
Lakrafli, H., Tahiri, S., El Houssaini, S., & Bouhria, M. (2017). Effect of thermal insulation using leather and carpentry wastes on thermal comfort and energy consumption in a residential building. *Energy Efficiency*. https://doi.org/10.1007/s12053-017-9513-8.
McDonough, W. (1993). Essay: A centennial sermon: Design ecology ethics and the making of things.
McDonough, W., & Braungart, M. (2002). *Cradle to Cradle, remaking the way we make things*. New York: North Point Press.
Paganin, G., Angelotti, A., Ducoli, C., et al. (2017). Energy performance of an exhibition hall in a life cycle perspective: embodied energy, operational energy and retrofit strategies. *Energy Efficiency,* pp 1–22. https://doi.org/10.1007/s12053-017-9521-8.
Pajek, L., & Košir, M. (2017). Can building energy performance be predicted by a bioclimatic potential analysis? Case study of the Alpine-Adriatic region. *Energy and Buildings, 139,* 160–173.
EPEA Switzerland (2017). EPEA Switzerland GmgH. Retrieved on Nov 15, 2017 from www.epeaswitzerland.com.

Ansgar Igelbrink, 1964 has completed Diploma in Business Administration, and from 1990 onwards, he has worked within the building distribution segment until 2000, when he changed to a segment leading chemical company for wooden flooring. Since 2007, he has developed and led the most successful brand Bauwerk Parkett within the wooden flooring industry. One of the success factors was the focus on healthy living, which was trustworthy documented with the C2C certification in 2013.

Albin Kälin, 1957, Merchant on textiles was awarded in 2001 with UBS Key Trophy as the 'Rhine Valley Entrepreneur of the Year.' From 1981 to 2004, he was Managing Director of Rohner Textile AG in Switzerland. Under his leadership, the company won, since the 1990s, 19 international design awards. In 1993, he stimulated the development of the product line Climatex® (https://www.climatex.com) and thus the first Cradle to Cradle® products worldwide. From 2005 to 2009, he worked as CEO of EPEA Internationale Umweltforschung GmbH in Hamburg. In 2007, he was additional CEO of EPEA Netherland. From 2009 to the present-day, Albin Kälin is founder and CEO of EPEA Switzerland GmbH.

Marko Krajner, 1972 starts his career in 1999 as wood science and technology engineer in furniture company Gorenje in Slovenia. Later he was quality manager, project manager, purchasing manager in different companies in Slovenia, in foundry, automotive, boating, wood and machining sectors. In 2011, he found 3ZEN consulting company based on Lean production and administration, TRIZ principles, 6-sigma and other continuous improvement and systematic innovation tools. He is Lead auditor for wood based certification schemes FSC since 2011 and PEFC since 2013. In 2017, he became General accredited assessor for Cradle to Cradle Certified™ certification Behalf of EPEA Switzerland. From the starting of 2018 to present-day, Marko Krajner is founder and CEO of 3ZEN d.o.o.

Roman Kunič is an associate professor, researcher and a head of Chair of buildings and constructional complexes. He finished his bachelor's degree in 1986 and in 1990 a master's degree, both at UL FGG. In 1997, he finished MBA on Clemson University in South Carolina, USA. In 2007, he finished his Ph.D. thesis 'Planning an assessment of the impact of accelerated ageing of bituminous sheets on constructional complexes.' After 25 years of experience in the economy,

mainly related to the industry of building insulation materials, he returned to the faculty. R & D work: new thermal, sound and waterproof insulations, advanced materials (e.g., VIP and PCM), environmental and sustainable assessment, analysis of accelerated ageing and lifetime prediction, and analysis of dynamic thermal response of buildings. He is an innovator of five patent applications. He works as a reviewer in 'Gradbeni vestnik', Energy Efficiency, Journal of RMZ—materials and geoenvironment. Also works as a lecturer in the areas of building envelope design, advanced materials, building renovation and sustainable building assessment. He is also mentor or co-mentor on more than 80 theses. He holds membership in professional and scientific associations: IZS—Slovenian Chamber of Engineers, ISES—International Solar Energy Society, 'Čar lesa' 'The Magic of wood' Ljubljana, a member of the organizing committee.

Selected Bibliography

ZRIM, Grega, MIHELČIČ, Mohor, SLEMENIK PERŠE, Lidija, OREL, Boris, SIMONČIČ, Barbara, KUNIČ, Roman. Light distribution in air-supported pneumatic structures : comparison of experimental and computer calculated daylight factors. Building and environment, 2017, 108, 1–43. https://doi.org/10.1016/j.buildenv.2017.04.005 [COBISS.SI-ID 8052321].

KUNIČ, Roman, OREL, Boris, KRAINER, Aleš. An Assessment of the Impact of Accelerated Ageing on the Service Life of Bituminous Waterproofing Sheets. Journal of materials in civil engineering, 2011, 23, 1746–1754. https://doi.org/10.1061/(ASCE)MT.1943-5533.0000326. [COBISS.SI-ID 5509985].

KUNIČ, Roman, MIHELČIČ, Mohor, OREL, Boris, SLEMENIK PERŠE, Lidija, BIZJAK, Aleš, KOVAČ, Janez, BRUNOLD, Stefan. Life expectancy prediction and application properties of novel polyurethane based thickness sensitive and thickness insensitive spectrally selective paint-coatings for solar absorbers. Solar energy materials and solar cells, 2011, 95, 2965–2975. https://doi.org/10.1016/j.solmat.2011.05.014. [COBISS.SI-ID 5509729].

KUNIČ, Roman, KOŽELJ, Matjaž, OREL, Boris, SURCA, Angelja Kjara, VILČNIK, Aljaž, SLEMENIK PERŠE, Lidija, MERLINI, Dušan, BRUNOLD, Stefan. Adhesion and thermal stability of thickness insesitive spectrally selective (TISS) polyurethane-based paint coatings on copper substrates. Solar energy materials and solar cells, 2009, 93, 630–640. [COBISS.SI-ID 4117018].