HOW TO CREATE A TOXFREE HOME?

Toxfree, circular and climate-friendly renovation of my home

Interreg Baltic Sea Region

Co-funded by the European Union

SUSTAINABLE WATERS

NonHazCity 3

NonHazCity

Content

CHAPTER 1: INTRODUCTION

We spend up to 90 % of our lives indoors in buildings. We all want to live and dwell in healthy environments that also do not destroy the livelihoods of future generations. These are two good reasons to minimise the climate impact and the demand for natural resources as well as the presence of hazardous substances that are harmful to our health and the environment in which we live and work. The opportunity to do this comes with every small or large renovation project. When renovating or extending our flats and houses, we have an almost endless range of materials, colours, and designs at our disposal. From naturally grown products, that mother earth has created over millions of years to fully synthetic alternatives, every option has its own characteristic climate- and chemical footprint. A life within the boundaries of the earth system will also require reducing the resource consumption by reusing resources and products as much as possible. The circularity potential of construction materials and a circular construction approach should thus be considered at any time.

We all aim make our homes beautiful and comfortable. To this end, we choose products with practical properties, such as water-repellent wall paints or floors without electrostatic charging. These properties are often created by chemical additives. But unfortunately, tens of thousands of tons of the chemical solvents, plasticisers, flame retardants etc. leak out of the building materials every year during and after the beautification of our living space. Even years later, the evaporating substances can trigger severe physical reactions. Possible effects include allergic reactions, headaches, and fatigue, but also long-term effects such as cancer or metabolic disorders. Studies show that indoor air in buildings is often many times more harmful to our health than outdoor air. Children, babies, and foetuses are particularly susceptible to the health effects of hormone-active chemicals. The consequences, such as reduced fertility, sometimes only become apparent after many years.

But it is not only our health that suffers from chemical emissions, but also the environment. Via sewage, dust and air, the substances from the interior get outside and the rain washes the substances off roofs and facades. Thus, the cocktail directly enters groundwater, rivers and lakes. Only 38 % of surface waters in the EU are not chemically polluted. The chemicals from buildings are not solely responsible for this, but they do contribute.

This guide will help you to choose the best building material for your project by considering the aspects of chemical content, climate impact and circularity potential.

About the project

The building sector is responsible for 38 % of CO_2 emissions worldwide, and in Germany construction and demolition waste accounts for more than half of the total waste volume. The idea of sustainability has therefore become increasingly prevalent in this sector in recent years. Energy efficiency, the use of renewable raw materials and circularity are increasingly being considered both in new buildings and in renovation projects. The focus is usually on climate-friendly construction and energy-efficient houses.
The environmental and health-damaging effects of chemical ingredients are considered too rarely and too superficially. Yet a toxic-free construction method would be a necessary prerequisite for circular building and thus for a construction method that protects the climate, conserves resources and preserves biodiversity.

This DIY guide for low-toxic renovation was developed within the framework of the Interreg project NonHazCity 3. In it, we develop solutions to promote toxic-free, climate-friendly, and circular construction. Our holistic approach includes actors from the public sector as well as from industry, business and private individuals. The project is being implemented in all eight EU Baltic Sea countries by a consortium of 22 partners and a further 17 associated organisations. Pollutants in building materials are an invisible danger to humans and nature. With NonHazCity 3 we want to make the problem visible and solutions possible.

More information about the project: www.nonhazcity.eu

1.1 WHY CARE ABOUT THE ENVIRONMENT WHILE BUILDING OR RENOVATING YOUR HOME?

Construction material and natural resources:

The production of construction materials often involves extracting and consuming large amounts of natural resources such as timber, minerals, and fossil fuels. Over-reliance on these resources can lead to their depletion and cause irreversible damage to ecosystems.

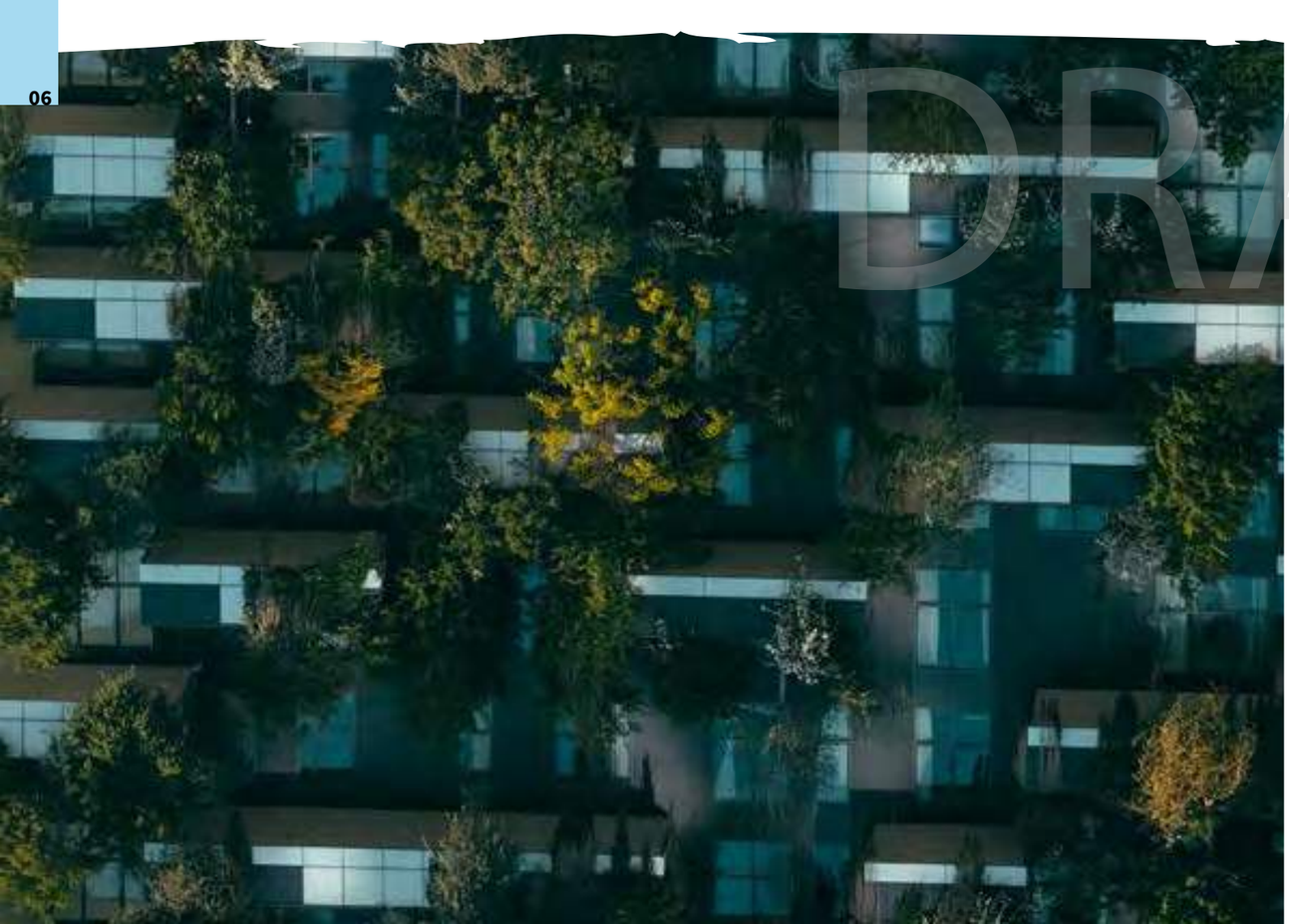
Environmental Impacts of Construction Materials and Practices

Toxicity: construction material may have toxic impacts on various ecosystems at all stages of life. One widely known example is found in sealants and adhesives. These tend to include volatile organic compounds [VOCs (more information about VOCs s. chapter 4.2)], which can contribute to air pollution and potential climate impacts. While not all VOCs directly contribute to global warming, some can indirectly contribute to climate change through their involvement in the formation of secondary pollutants like tropospheric ozone (O3) and fine particulate matter, which have both environmental and health impacts. Copper roofing and façade materials serve as another example. Being used on the outer parts of buildings they leach heavy metals into the environment, impacting especially aquatic systems.

Circularity: If construction materials are not designed circularly, construction generates a substantial amount of waste, including construction debris, packaging materials, and demolished structures. Re-using, recycling (without adding hazardous substances) and proper waste management practices are crucial for minimizing environmental impacts.

Climate: Climate change is altering ecosystems worldwide, affecting the distribution and behaviour of functional species. Changes in temperature, precipitation patterns, and extreme weather events can disrupt the timing of critical ecological processes, such as flowering, migration, or hibernation. Such disruptions can have cascading effects throughout the ecosystem and impact the performance of functional species, ecosystems, and their services. Construction materials significantly contribute to greenhouse gas emissions. For instance, cement and steel production release significant amounts of CO_2 due to energy-intensive processes. Besides CO_2 also other greenhouse gases such as Methane and fluorinated gases are released during the production of construction materials.

By prioritizing toxfree, circular and climate neutral construction materials and practices, healthier and more comfortable living and working environments can be created.



1.2 IMPACTS ON OUR HEALTH

Sources of hazardous substances in building materials

Many construction and refurbishment materials contain chemicals that can be harmful to human health, and these substances can find their way into our indoor environments through various pathways. During the refurbishment, the first days or even months after, the indoor air can be full of chemicals emitted from the walls, ceiling, flooring, or furniture. Household members easily absorb them via inhalation, transdermal, or oral, increasing their risk of adverse health effects. The transformation of the home, especially for a newborn, may pose a more serious danger than we realize, as pregnant women and fetuses are the most vulnerable group to harmful effects.

During the process of creating a cozy for you and your family, there is a risk of the emission of many hazardous **substances,** such as.

- Volatile Organic Compounds (VOCs): Found in paints, adhesives, and solvents, VOCs can release harmful gases into the air, contributing to indoor air pollution. Long-term exposure to VOCs has been linked to respiratory issues, headaches, and even more severe health problems.
- Formaldehyde: Often present in composite wood products, insulation materials, and certain glues, formaldehyde is a known carcinogen and respiratory irritant. Prolonged exposure may lead to respiratory issues, allergic reactions, and an increased risk of cancer.
- Heavy metals: Lead, mercury, and cadmium can be present in paints, pipes, and other building materials. These metals pose serious health risks, particularly to children, causing developmental and neurological issues.
- Flame retardants: Commonly used in furniture, carpets, and insulation materials, flame retardants can disrupt the endocrine system and have been linked to various health problems, including hormonal imbalances, fertility issues, and even cancer.
- Plasticizers: Phthalates are commonly used in plastics and vinyl materials found in flooring, wall coverings, and other construction products. Phthalates have been linked to disruptions in hormonal systems, particularly affecting reproductive health risks of lifestyle diseases.
- Bisphenols: These are often incorporated into polycarbonate sheets and panels and in epoxy resins, commonly used as adhesives, coatings, and sealants. They are xenoestrogens.
- Pesticides and biocides: Wood treatments and coatings often contain pesticides or biocides to protect against decay and insects. Some of these chemicals may have endocrine-disrupting properties.

In fact, as the methodology to study these topics and the problems arising are relatively new, the consequences of this long-term exposure and the complex composition and mixture of many different chemicals found in a household is not a very well researched field. Relevant studies must span several decades, and proving cause-effect relationships is very difficult in this context.

Often products are put on the market before appropriate scientific studies can be completed. This means that national and EU laws are currently lagging and are not sufficient to protect citizens from exposure to potentially harmful substances.

Therefore, we as citizens and consumers must act! We must be aware and minimize our use and contact with potentially hazardous products and materials as much as possible.

1.3 BEFORE YOU GET STARTED

You are probably aware that construction activities are highly regulated and new construction almost always requires a permit. However, renovation may likewise require permission, and it is even possible, that change of ownership triggers an obligation to modernize. Requirements may also differ between self-owned and self-inhabited places on the one hand and rental properties on the other.

No construction nor renovation project gets around the selection of systems or even of materials for a given project. In countries like Sweden a material logbook became popular as it enables the buyer of a property to easily understand which materials were used where and which substances came with it. Although you may legally not (yet) be required to keep such a log-book or construction magazine as it may also be called with the complete construction material, if you would ever sell your property or even if you need to replace or redo a part of your construction, it may come very handy and could even be a decisive factor for a future buyer.

Fortunately, under the EU's REACH legislation, you have the right to obtain information about any very dangerous substances in your materials, known as Substances of Very High Concern (SVHC). For liquids and viscous materials (pastes), these are easily found in the Safety Data Sheet (SDS). As this obligation currently only applies to substances that have already been assigned one of the relevant classifications (according to the EU's lists, which are updated every six months), substances that have not yet received such a classification are not yet included.

- Use your right to ask about SVHCs in your products: Suppliers are obliged to provide the relevant information on SVHC and on the safe use of the article within 45 days.

Therefore, in addition to the legal rights we have today, it is worth asking your material or manufacturer for the full declaration of substances in the building materials you purchase or consider trying a supplier who is willing to provide the full substance declaration for your logbook. A well-maintained materials logbook will also help with any renovation work and may even increase the resale value of your building in the future. It can also come in handy if you ever want to eliminate specific contaminants linked to a particular health problem.

What to do first

When embarking on a new build and/or renovation project, you will quickly realise that there is an overwhelming complexity of factors influencing each choice. However, like many homeowners, you probably want and/or need to get things done and may feel the urge to get started quickly in the hope that this will help to naturally limit your options in the future. Whilst this may be true, it is worth not rushing into decisions and ruling out whole system changes too early, as these may bring unexpected economic benefits and help you to achieve the best possible outcome on the aspects that are relevant to you.

- Identify all interlinkages within your construction/renovation project.
- Select flooring options after finalizing your choices for insulation and heating systems and eventual generation of energy and warmth
- Explore the integration of warmth, such as warm-water and heating, with roofing solutions, heat-pumps, wall insulations, and other installations.
- Consider generating your own electricity and warmth to potentially reduce cost.
- When planning for smart-home solutions, heat-pumps, solar-collectors, internet connectivity, electro smog-shielding or specialized lighting for circadian rhythms, be aware that electricity requirements may vary.
- Consider the health implications of material choices when making construction decisions.
- Ensure that the timelines and availability of materials and services align with your project's needs.
- Define your minimum requirements, priorities, and nice-to-have features to guide your decision-making process.

When comparing options and prices, always collect:	avail-ability	longe-vity	repair	recycling	material quality	guaran-tees	toxics content	

Take eco-certification into account

Eco-labels offer another way of selecting sustainable products. Eco-certification is a voluntary method of certifying and labeling environmental performance and standards, which is practiced worldwide. An eco-label certifies products or services that are more environmentally friendly according to specified criteria. The eco-label organisations often groups articles or services into different categories and develop criteria suitable for the respective categories [more information about (eco-)labels s. chapter 6] .

Tips for securing construction product information when contracting work

- You can fix with your contractors, that one week before the start of the works (or as you need) they shall provide you with the following information about any chemical products and materials they plan to use for your project.

They should provide you with:

- **a)** the exact product name / brand and producer of the product or mixture or material or product photos with the same information
- **b)** the technical specification from the producer if available
- **c)** for chemical products and mixtures, a material safety datasheet according to article 31 and Annexe II of the regulation (EG) Nr. 1907/2006 (REACH-regulation)
- **d)** fIt is essential to set some criteria before hiring a professional. On the Internet you can find free documents like "Sample service description for low-pollutant construction and renovation for hiring a craftsman etc." That kind of service description can help you to find the right professional for your needs.

CHAPTER 2: INDOOR RENOVATION

2.1 WALLS

The visible surfaces in rooms are the linchpin of any renovation. They determine the image and atmosphere of a room. But they can also be the starting point for toxic outgassing. The larger the surface, the greater the potential for indoor air pollution.

The most important are floor, wall, and ceiling coverings such as plasters, paints, varnishes, and claddings; see Figure 1.

Invisible substructures can also contribute to indoor air pollution. These include the adhesives used to attach the cladding or coverings, the preparation of the substructure or even the wall construction itself.

Figure 1.: Typical application areas in living rooms, bedrooms and children's rooms; 1… 2… 3… 4… (Photo Auraplan)

Figure 2.: Too much cladding? 5… 6… 7… (Photo Auraplan)

- Working on visible structures, wallpapering, and painting are DIY classics. The more the substructure of the wall needs to be redesigned, the more the question arises as to whether it should be done by a DIY or a professional!
- If you are considering installing internal insulation, ask the specialists! [Blow-in insulation (e. g. cellulose; isofloc), wood fibre or calcium silicate boards]
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Figure 3.: Cellulose blow-in insulation on the inside of the wall (photo Auraplan)

A common variant of wall construction is brick/plaster/covering plaster or wallpaper/paint. Almost all common types of plaster (gypsum, lime, cement, and combinations) contain additives. They make it easier to apply and affect its durability and life.

The simpler the wallpaper, the fewer harmful substances it contains, e. g. woodchip wallpaper. Textured wallpapers contain plastics/coatings. Wallpaper paste is non-toxic if it is just cellulose and not mixed with other additives.

When renovating, if the floor plan needs to be changed, dry construction or the use of different boards and panels is an option.

Regular gypsum doesn't contain any additional additives. The product is generally non-toxic when used as intended; however, some health risks may occur during the cutting and installation phases when fine particles (dust) from the boards may be inhaled. Appropriate personal protective equipment (e. g. respirators) should always be used. Gypsum board production is resource intensive, particularly in terms of energy and water use. It contains energy-intensive cement. On the other hand, recycled materials can be incorporated into the boards and the gypsum itself can be reused in the production of new boards if the paper facers are removed.

Wood-based panels are various types of construction and renovation materials based on wood particles of various sizes that are bonded together by chemical resin and the application of heat. The most common types of panels found on the consumer market are **OSB** (oriented strand board), **MDF** (medium density fibreboard), **plywood and CLT** (cross-laminated timber). Each type of board has a different appearance, physical and mechanical properties and uses. These types of panels emit formaldehyde into indoor air after they are installed. Formaldehyde emissions from building materials have been severely restricted and the maximum allowable levels are now extremely low. However, many manufacturers are striving to achieve even lower emission limits.

In addition to formaldehyde, other volatile organic compounds [VOCs (more information about VOCs s. chapter 4.2)] can also pose health risks if inhaled continuously from indoor air.

The production of wood-based panels is very energy intensive. However, some types of panels can use recycled wood in the production process and most types can be recycled into new wood panels at the end of their life cycle.

List of wall materials
(green = good choice, yellow = okay, red = bad choice)

Material (for example boards)	Hazardous substances?	Circularity (can be recycled?)	climate impact	Durability	Costs
regular gypsum board					
MDF/OSB					
OSB					

Of course, rating materials from good to bad can depend on many different factors (e. g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

General recommendations

- Always wear a dust mask during installation as fine silica dust is harmful to breathing.
- Choose products with ecolabels.
- When considering purchase of wood-based boards, choose brands that declare at least E1 emission class or better yet E0,5.

(Eco-) Labels

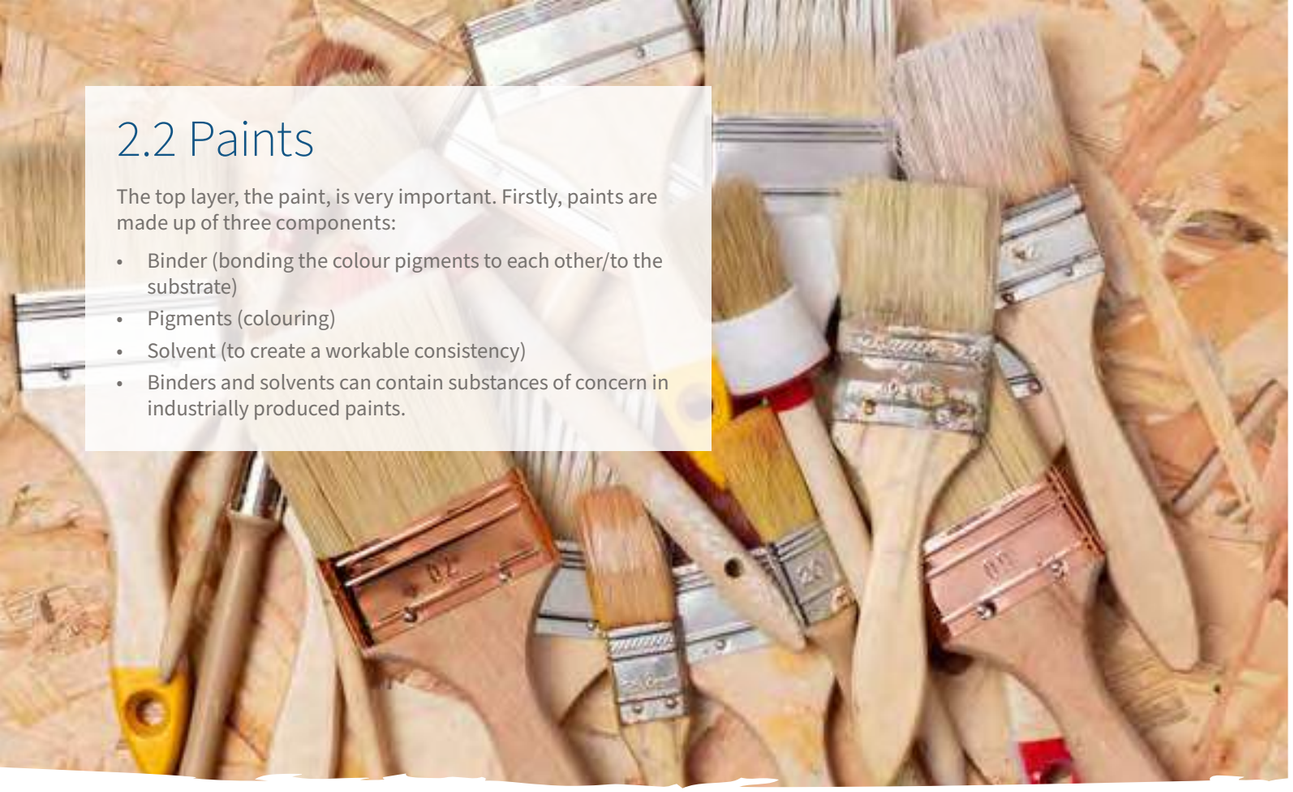
There are several independently verified labels that help identify products that have a lower overall impact on indoor air quality. These include A+, M1, Eurofins Indoor Air Gold and others.

The M1 label can help you to choose a better product. The Finnish classification of building materials (M1, M2, M3) will help you find products that emit less harmful substances into the air. You should look for products in the M1 class.

The maximum permissible VOC limit for matt interior paints is 30 g/l, but it is considered good if this value is below 10 g/l [more information about (eco-) labels s. chapter 6].

Where to get?

The products can be found in hardware stores, specialised retailers and eco hardware stores (if available).



2.2 Paints

The top layer, the paint, is very important. Firstly, paints are made up of three components:

- Binder (bonding the colour pigments to each other/to the substrate)
- Pigments (colouring)
- Solvent (to create a workable consistency)
- Binders and solvents can contain substances of concern in industrially produced paints.

Pigments are granular solids that are incorporated into the paint to provide colour. Pigments can be classified as either natural or synthetic. Natural pigments include various clays, calcium carbonate, mica, silica, and talc. Synthetic pigments include artificial molecules, calcined clays, blanc fixe, precipitated calcium carbonate, and synthetic pyrogenic silicas. Hiding pigments, which make the paint opaque, also protect the substrate from the damaging effects of ultraviolet light.

Oil based paint

What defines an oil-based paint is that it uses solvents derived from oil (white spirit). Oil-based paints contain more VOCs (more information about VOCs s. chapter 4.2) than water-based paints, which can be harmful to human health. Therefore, in some countries, professional use of oil-based paint is only allowed for outdoor applications. For every oil-based paint there is usually a water-based alternative that is also of good quality.

It dries slower than water-based paints, but faster than some natural paints. Paint removal is quite messy.
Oil-based paints are the most polluting to produce.

Water-based paints contain microscopic plastic particles of binder, filler and pigment dissolved in water. Water-based paints are soluble in water but become waterproof when dry. Various types of binder are used, such as acrylic, vinyl, PVA or alkyd.

Low VOC waterborne paints: Waterborne paints such as acrylic, latex, waterborne enamel, emulsion paints are commonly used and readily available. Waterborne paint compositions typically contain binders (typically synthetic polymers, e. g. acrylic, vinyl acrylic, PVA); pigments; solvent – water and small amounts of other organic solvents; fillers, e. g. calcium carbonate; other additives, e. g. surfactants, thickeners, stabilizers, preservatives.

Synthetic water-based paints are not free of harmful substances. They contain agents that can emit VOCs, such as antibacterial, antimould, fast-drying or preservatives.

Water-based paints are better than oil-based paints but are still quite resource intensive to produce. They have a high embodied energy due to the presence of energy intensive polymers, but also pigments such as TiO2.

Latex or water-based paints labelled as ‚fast drying' can emit formaldehyde.

There are several sustainable paint options, including:

Zero-VOC paints: Although VOC-free, these paints still contain preservatives such as Isothiazolinones, which are used for in-can preservation.

Clay-based paints: Clay-based paints can be completely free of VOCs, synthetic binders, and preservatives (clay inhibits the growth of micro-organisms), making them one of the most sustainable coating solutions. They can be sold in liquid or powder form. Clay paints are not widely available commercially but are gaining interest in the sustainable building sector and the niche market is expanding.

Lime wash: is a simple coating solution for interior or exterior walls. Suitable for do-it-yourself application as limewash is only lime and water. Additional ingredients can be added to improve its properties. Lime wash is an environmentally friendly solution, but PPE should be used during preparation and application as lime and lime solution are corrosive and can burn skin or eyes.

Natural pigments: These are pigments extracted from plants, animals, or earths. They can be used for DIY applications and are generally safe materials to work with if inhalation of their dust is avoided.

List of wall materials (green = good choice, yellow = okay, red = bad choice)

Material (for example paints)	Hazardous substances?	Circularity (can be recycled?)	climate impact	Durability	Costs
oil based paints					
water based					
Zero VOC paints					
Clay based paints					
Lime wash					
Natural pigments					

Of course, rating materials from good to bad can depend on many different factors (e. g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

General recommendations

- Pregnant women should not paint with oil. They should also stay out of an oil-painted room for at least two days after painting and ventilate the room properly before bringing the baby home.
- Warnings on the container such as "ventilate well during application" – "mould resistant" etc. may indicate that the product is not environmentally friendly, despite the label. It is advisable to check the entire formulation.
- What does low VOC mean? Below 50g/l it is considered low, below 5g/l it is considered zero. Check the list of ingredients.
- Just because a paint is low VOC does not mean it is non-toxic. It is also important to check the ingredients.
- If the same low VOC paint is used on several pieces of furniture, floors and walls in the same room, the total amount of VOCs in that environment may be hazardous.
- Hazardous pigments based on heavy metals are no longer used, but they may still be present in old paints that should not be used and should be disposed of properly.

Incidentally, "organic" colours are not natural colours. The adjective organic refers to the carbon compounds of petroleum products. Organic paints are "organic" in the sense that they provide food and support for mould fungi indoors, or algae and moss outdoors. This is why fungicides are sometimes added.

(Eco-) Labels

Tip Pay attention to the VOC content in the paint and/or choose eco-labelled paints (EU Ecolabel, Nordic Swan or Blue Angel (Germany)) as these paints have limited VOC content and other elements such as life cycle aspects and hazardous substances may not be included in the product. The lower the VOC content in the paint, the safer it is for your health!

Label Émissions dans l'air intérieur is a good guide for choosing safer paints. It shows how many harmful substances are released from the product. An A+ product will definitely be better than a C product.

Another label that can help you choose a better product is the M1 label. The Finnish classification of building materials (M1, M2, M3) will help you find products that emit less harmful substances into the air. You should look for products in the M1 class.The maximum permissible VOC limit for matt interior paints is 30 g/l, but it is considered good if this value is below 10 g/l. [more information about (eco-) labels s. chapter 6]

Blue Engel ecolabel | Nordic Swan ecolabel | EU flower ecolabel | M1 label

Where to get?

There are hardly any paints available in a normal hardware store that do not have an eco-label (e. g. Blue Angel in Germany). This means that the formulations have been improved and the solvent content must be below a certain percentage, e. g. < 10 %. Common paints and varnishes are now mostly water-based and easily meet such a criterion.

If you want to be sure what a paint contains, you can make and mix paints using traditional recipes. Under the motto "Know what's in it", there are many websites with tips and films on how to make casein, glue, or other natural paints.

2.3 FLOORING

Laying carpet is considered a typical DIY project. The same goes for laying laminate flooring with a simple click system. Many other types of flooring should be installed by professional contractors. The more the sub-floor needs to be levelled, the more the question arises as to whether it should be DIY or professional!

Especially in wet rooms or kitchens, tiles or natural stone coverings can be used as the top layer. They need to be laid on a level, stable surface. Uneven or too “mobile” subfloors can cause the tiles to crack. The larger they are, the more likely they are to break.

Natural stone is one of the most durable floor coverings due to its timeless, water-repellent, and extremely robust properties, but it is an obviously finite material. How sustainable the natural stone is to be assessed ultimately depends on its production and where the stone is harvested (transport distance as short as possible).

Clay tiles are one of the oldest commonly used floor coverings. Using regional raw materials gives the choice a bonus point in terms of sustainability. Clay tiles are hard-wearing, durable, and easy to care for. Their composition does not contain any toxic additives and they are usually not glued but laid in a mortar bed.

Ceramic tiles are the most popular type of tiles. In general, they are considered to be low emission. However, unglazed tiles are usually given a “ceramic sealant”, and if necessary, also an impregnation. The products used for treatment usually contain VOCs (more information about VOCs s. chapter 4.2). The ceramic tile can be easily recycled if it is untreated.

Concrete floors are a special case, but they cannot be used in grease spray or wet areas without further treatment. In each case, agents that may contain VOCs are used for treatment.

Wood floor is called the most sustainable and ecological option but the treatment with paints and varnishes can raise some health concerns. See paints section. Wood surfaces can be treated with closed pores by sealing with lacquers or with open pores by using oils and waxes. Oiled surfaces are more sensitive in the short term than lacquered surfaces, but they often do not contain any harmful substances and can be very easily partially touched up. If a lacquer has expired, the entire surface must be sanded and resealed.

Figure 4: Historic fir plank floor sanded and oiled (Photo Auraplan),

Figure 5: Solid oak parquet oiled (Photo Auraplan))

There are various products on the market that imitate wooden flooring but consist of different layers glued together.
The entire product with all layers should always be examined for emission sources.

As one example, **laminate panel** is generally made up of different layers, densely compressed at high temperatures to form a homogeneous material, usually with an easy-to-use click system that is also easy to remove and to be laid without a glue. The material is impregnated with resin and the layers are glued together using natural or artificial binders. Some of these materials contain substances hazardous to health: phenol, formaldehyde, toluene.

The composition of **natural linoleum** is simple: linseed oil, jute and cork, raw materials from renewable resources. It is a fully recyclable product. It can also be used combination with underfloor heating. The large panels must be attached to the sub construction with adhesive. The quality of the glue must be considered. The surfaces can be obtained with no finish (water-based). Untreated versions can be treated with a hard oil after installation.

"PVC linoleum" is made of polyvinyl chloride, a synthetic material derived from petroleum. It can emit VOCs after installation and is not biodegradable. PVC contains additives that can be hazardous to health and the environment (phthalates, flame retardants, heavy metals). Harmful chemicals are created during the manufacture of chloride in PVC (Dioxins). PVC can be difficult to recycle, as it is made from a combination of plastics and chemicals.

Textile floor covering: Classic carpets consist of two layers, the wear layer, the textile "pile", which determines the character and colouring, and the backing. Both components determine the ecological quality of the carpet. The pile can be made of renewable raw materials such as sisal, jute, coconut fibres or hemp. The backing is often made of plastic foams, which can be problematic. However, there are also backings made of jute or other textile meshes. Carpets which made with synthetic materials can contain PFAS (Per- and polyfluoroalkyl substances) in the case of their treatment for stain, soil, water resistance. PFAS are persistent in the environment and cause toxic effects on people.

List of flooring materials
(green = good choice, yellow = okay, red = bad choice)

Material (for example »flooring«)	Hazardous substances?	Circularity (can be recycled?)	climate impact	Durability	Costs
natural stone					
Ceramic tiles					
Concrete					
Wood flooring					
Laminate					
Natural linoleum					
PVC flooring					
Textile natural materials					
Textile syntenic materials					

Of course, rating materials from good to bad can depend on many different factors (e.g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

General recommendations

- If stones and tiles are fixed to other material, make sure to use an environmentally friendly product too.
- Choose untreated natural stones. Surfaces can be polished or made rough mechanically.
- What does low VOC mean? Below 50 g/l it is considered low, below 5 g/l it is considered zero. Check the list of ingredients.
- Choose untreated tiles.
- Use locally harvested stones or locally produced tiles to avoid large CO_2 emissions through long transport distances.
- Make sure that tiles are free of harmful substances and, if possible certified with an environmental label.
- If a wooden floor has been treated/sealed, check the finish. Always check that the paint is suitable for indoor use.
- In case of sanding down an old layer of painting, always use protective dust mask during the work.
- Click or interlocking systems (laminate/cork/vinyl or other) do not require glues or adhesives for installation. As well as being quick to install, it is also easy to remove or partially repair.
- But they are made up of different layers. Check not only the properties of the visible surface of the floor, but also the different layers.
- Prefer non-vinyl flooring (not PVC). If you choose a PVC floor, choose a phthalate-free PVC
- Avoid PFAS-based stain or water repellents in the flooring materials.
- Check if eco labelled products are available.
- It is important to remember that if the laminate or PVC flooring catches fire, a highly toxic gas is released which can cause severe poisoning.

(Eco-) Labels

Sometimes there are eco-labels for laminate - the Nordic Swan eco-label and the EU eco-label. The following labels attached to the product also indicate good quality laminate: A+ label; M1 label.

A+ (Emission regulation certificate, used as recognition for very low emissions. A+ is the highest category and represents the lowest emissions).

M1 (Proof that our flooring products do not release toxic substances and are odourless. M1 is the highest category of this Finnish classification and represents the lowest emissions [more information about (eco-) labels s. chapter 6)].

Where to get?

The products can be found in hardware stores, specialised retailers and eco hardware stores (if available).

2.4 SPECIAL FEATURE – WET ROOMS

The bathroom used to be a storage room for everything that had no other place to go. This is what the German writer Theodor Fontane put into the mouth of a novel character in 1899. The maid, Hedwig, would have brought hot water to her master's washstand, which was in his bedroom. This kind of "toileting" did not require any special preparation of the wall and floor. Showering on the other hand is a kind of torrential downpour in the middle of the building.

Regular showering is the best way to ensure that water and water vapour dry out and cannot penetrate joints and cracks and damage the building fabric. This makes bathrooms a very special type of room.

Renovating a bathroom

- **Consult a professional** because Sanitary accessories must be installed according to complicated technical rules.
- Water and steam can cause damage to the building fabric.
- There are no simple traditional or natural ideas on how to prevent this type of space from being damaged by water.
- It is extremely important to know how and to ensure a correct execution of the waterproofing.

Figure 6: Washing dishes instead of bathing (photo detail of a painting by Schwind 1860)

COATINGS, ADHESIVES AND SEALANTS

If new bathrooms are to be built using a dry construction method, boards with a water-repellent surface should be chosen, see Figure right.

To apply the final finish, such as tiles or plaster to the walls, the substrate must be prepared using primers, adhesion promoters, liquid films and adhesives.

Pro & Contra: Absorb or repel moisture?

- Tiles are ideal for bathroom floors and walls because they do not absorb water. Clay or lime plasters absorb moisture and release it slowly.
- Caution: They are of limited use in areas subject to splashing or standing water.
- The idea? The traditional Moroccan process (Tadelakt) uses saponified lime plaster to create a water-repellent surface that absorbs water vapour and can be used in wet areas
- This requires very careful maintenance. Carelessness can lead to serious structural damage!

Figure 7: Fermacell planking in the bathroom (Photo Auraplan)

List of wet room materials (green = good choice, yellow = okay, red = bad choice)

Material (for example primers/	Hazardous substances?	Circularity (can be recycled?)	climate impact	Durability	Costs
Acrylic adhesives					
Latex					
PU					
Cementitious					

Of course, rating materials from good to bad can depend on many different factors (e.g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

Primers:

- Acrylic or latex: Primers, e.g. on plasterboard, may contain acrylic or latex polymers.
- Solvents: Some primers may contain solvents such as isopropyl alcohol or other volatile organic compounds [VOCs (more information about VOCs s. chapter 4.2)] such as ethanol, xylene, acetone, etc. to ensure good adhesion.

Liquid membranes:

- Polyurethane: Liquid polyurethane membranes may contain isocyanates and polyols. These form a durable and waterproof coating.
- Acrylic: Acrylic-based liquid membranes often contain acrylic polymers which provide water resistance and durability.

Tile adhesives:

- Cementitious binders: Tile adhesives often contain cementitious binders, such as Portland cement or gypsum, which provide adhesion and strength.
- Polymers: Latex or acrylics are often used in tile adhesives to improve flexibility, bond strength and water resistance.

CHAPTER 3: OUTDOOR

The materials used for the exterior surfaces of buildings determine their appearance and how well they ‚fit' into their surroundings. The choice of materials also influences how the building is affected by physical and environmental factors, its durability and wear. But the building can also have an impact on the environment and human health, for example through the leaching of certain chemical substances and the indirect environmental impacts associated with harvesting/extraction and production, or the possible environmental contamination at the end of its life. Therefore, the choice of materials for DIY exterior renovations is important.

The choice of roofing material, wood for facades or terraces, wall coatings or other building materials can all have an environmental impact. Some buildings are located in sensitive environments, such as near rivers and other bodies of water, so materials need to be chosen even more carefully to avoid leaching and outgassing of pollutants. One of the main concerns is the leaching of biocides from treated wood, coatings or even plasters. Equally important is the potential leaching of other components, such as plasticisers, stabilisers or other additives found in plastic exterior cladding, decking or tiles, and additives or residues found in bitumen or polymer-based roof coatings. Considering how many buildings are concentrated in cities, the amount of all hazardous chemicals leached from roofs and facades is very significant.

In the outdoor materials chapter, we will discuss DIY building products such as roofing materials, wall materials and technical materials (membranes, films), taking into account the product life cycle, chemical and other impacts. Energy efficiency and indoor quality.

The roofs can be sloped, flat or mixed. In any case, their function is to protect the interior of the building from rain or snow during the precipitation events and allow for it to run off/ slide off. Sloped roofs are in most cases tox-free as many materials used are relatively inert, such as steel sheets or ceramic tiles, but bitumen roofs for example can be a concern due to their chemicals content. Flat roofs, on the other hand, often require the use of more exotic materials such as layers of bitumen-based materials or synthetic polymers containing various additives.

When renovating the roof, choice of the roofing material depends on several factors – the budget and the scope of the works foreseen (change of roofing sheets only vs renovation of underlying structure, adding insulation, etc.), the underlying construction, slope angle of the roof and the environmental factors. Thus, in this chapter various roofing materials, their chemical properties and life-cycle impacts are going to be discussed.

3.1 ROOFING MATERIALS

Sloped roofs

	Bitumen	Intensive green roof	Extensive green roof	Gravel	Fibre dement boards	Tiles	Copper
Lifespan of roofing types in years	25	28	30	31	38	42	69

Metal roofing sheets are versatile and durable. Steel and aluminium are tox-free, while copper sheets or galvanised (zinc coated) steel sheets should be noted due to their biocidal properties. If a building with such roof is in a sensitive environment, it can have a negative environmental impact. This is especially relevant in Nordic countries where lakes are more sensitive to pollution due to the geological reasons. Although metal extraction, processing and manufacture of metal products requires a lot of energy, the environmental impact of the metal roofs is moderate, as the sheets are quite thin and weigh relatively little (less material – lower footprint). The exception is aluminium roofing, that has the highest associated emissions.

Ceramic and concrete tiles. Ceramic tiles are a classical building material used since the ancient times and still used today. It has a high expected lifespan of more than 50 years, depending on the latitude (shorter lifespan in colder climate areas). Ceramic tiles are non-toxic and chemically stable, while concrete tiles are also relatively stable material. The associated emissions of these two materials per sq. meters is higher than most other roofing covers. At the end-of-life significant amount of heavy waste is produced, but the tile rubble can be used for landscape forming purposes or pavement.

Fibre cement roofing sheets are made of cement, sand, and fibrous material. These became popular at the beginning of 20th century but had a major drawback – they were based on asbestos fibre. Nowadays, asbestos is replaced with cellulose or synthetic fibres. The sheets may also be coated with polymer material to improve it's durability and can last for up to 50 years with no or little maintenance. However, the sheets may contain biocides in order to prevent the growth of moss/ lichen or mould, that may leach into the environment. At the end of life, fibre cement roofing material is discarded as construction waste, while old asbestos sheets need to be properly disposed of. Fibre cement roofing material has an approximately two times lower carbon footprint than metal roofing sheets or ceramic roofing tiles.

Bitumen/ modified bitumen roofs. These are fossil fuel-based roof covers made from asphalt, a filler material such as sand or gravel, synthetic polymers, and various additives such as stabilisers and biocides. Bitumen roofs are a source of cancerogenic Polyaromatic hydrocarbons (PAHs) that are leached out by rain in trace quantities. Additionally, bitumen roofs contain biocides such as mecoprop, may contain alkylphenols, heavy metals and other hazardous components. Bitumen roof cover is commonly used due to the lower price, good waterproofing ability, their easy to lay down, maintain and repair. However, they have a lower lifespan than most roofs and typically last for around 30 years. At the end of service life, the material is usually discarded as a construction waste, thus hazardous additives or residues may continue to leach into the environment.

Polymer-based roof cover such as polycarbonate and acrylic are not typically used for roofs of residential houses. However, they can be used for other structures, such as terraces or decks, garages, garden sheds or wood storage structures, conservatories, and orangeries, especially if a clear roof cover is desired. The advantage is their light weight, and ease of mounting. The disadvantages are a shorter lifespan (10 years for polycarbonate and 20 years for acrylic), lower durability and vulnerability to hail. Polycarbonate roof cover may contain BPA residues or other additives, such as UV stabilizers, etc. At the end of life both acrylic and polycarbonate can be disposed as sorted waste.

Stone slate roofs. Slate roofs are traditionally used in areas where the raw material is available such as Germany or UK. These are very long lived and can last up to several hundred years. Tiles are typically attached with nails or wires. If not transported from thousands of miles away, slate is a very low impact roofing solution and at the end-of-life slate rubble can be used for landscaping purposes.

Wooden roof shingles. These are typically locally made from local wood by local craftsmen. Usually aspen (Populus tremulus) wood is used, but other species might be as well. Only shingles and thin metal nails are used, wood preservatives are not required. Thus, it is one of the most ecological materials. The lifespan is 30 years or more. The steeper the roof slope- the longer its' lifespan. At the end-of-life the old shingles can easily decompose or can be used as fuel leaving no waste behind.

Reed or straw (thatched roofs). Reed or straw roof covers are typically used in traditional construction or restoration of traditional buildings. The material is locally produced, there is little to no processing required. The main drawbacks are fire susceptibility, difficulty to find and hire a skilled craftsman, high pricing per square meter, a need for relatively frequent maintenance (less for steeper sloped roofs). The reed or straw roofs have good thermal properties and at the end of life the waste can easily decompose.

List of slope roof material
(green = good choice, yellow = okay, red = bad choice)

Material	Hazardous substances?	Circularity (can be recycled?)	climate impact	Durability	Costs
Steel roofing sheets					
Copper roofing sheets					
Aluminium roofing sheets					
Ceramic tiles					
Concrete tiles					
Fibre cement roofing sheets					
Bitumen/ modified bitumen roofs					
Stone slate roofs					
Wooden roof shingles					
Reed or straw (thatched roofs)					
Plastic roofing (e.g. polycarbonate)					

Of course, rating materials from good to bad can depend on many different factors (e.g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

Attention! Before buying a new roof cover, consult a specialist, who will be able to evaluate, which materials are the most suitable for your building situation. There are nuances such as slope angle, underlying construction and other specifics that should be taken into account, thus professional knowledge is necessary.

The roof cover replacement should also be done by a skilled professional, as there are fine nuances involved in the work that requires skill and experience. It is in most cases cheaper to hire a specialist so that mistakes are avoided and durability and longevity of the roof is ensured.

Flat roofs

Flat roofs contribute to a more modern aesthetic, usually require simpler construction and less material than the sloped roofs, thus they are less expensive to build. Additional advantages include the possibility to use the rooftop for various recreational or domestic activities. Flat roofs are more common in warmer climates with little rainfall, but they are occasionally chosen as a roofing solution for residential homes also in temperate climates. Contrary to what the name “Flat roofs” suggests, these roofs are not built completely flat in temperate climates. There is a low slope angle, typically much less than 10° to facilitate water drainage.

The flat roofs typically are more water retaining compared to sloped roofs, thus better waterproofing is required, and more exotic materials typically need to be used.

These include various synthetic membranes or special cover materials. Additionally, in areas with high snowfall, the snow needs to be shovelled off the roof in order to prevent dangerous structural loads. Debris such as tree leaves also need to be periodically removed. In colder climates the flat roofs may have a shorter lifespan than most sloped roofs and without proper maintenance lifespan may be reduced even more.

The materials used for their construction may contain more hazardous chemicals compared to sloped roofs. Among the materials used are EPDM, PVC, TPO, modified bitumen sheets or a Built-up Roofing (BUR) construction, polychloroprene, chlorinated polyethylene and chlorosulfonated polyethy-lene sheets.

The most common are:

EPDM (ethylene propylene diene monomer) is also known as synthetic rubber. EPDM cover is resistant to environmental effects, but it is not very resistant to mechanical damage. EPDM can last for 20–30 years. The carbon footprint of EPDM is relatively low as only a thin layer of material is used. At the end-of-life EPDM can be recycled. However, EPDM may contain flame retardants and polyaromatic hydrocarbons (PAHs) that are hazardous to human health and environment.

PVC (polyvinyl chloride). PVC sheets are durable, resistant to environmental effects and can last for 20–30 years. The carbon footprint of PVC sheets is relatively low as only thin layer of material is used. At the end-of-life PVC can be easily recycled. The downside of PVC is hazardous plasticiser content as well as other hazardous components such as chlorinated paraffins. During the manufacture and at the end-of-life of PVC, highly toxic chemicals dioxins and PCBs may form.

TPO (thermoplastic polyolefin) is a type of polymer membrane increasingly being used for roofing. It is highly resistant to environmental effects, to chemical and mechanical damage. TPO is durable and relatively long lasting. If properly maintained, it can serve for 20–30 years. TPO can be recycled, and its’ carbon footprint is relatively low as only a thin layer of material is used. TPO is one of the greenest roofing membranes, but it may still contain hazardous additives, such as stabilizers that extends its lifespan and improve its performance but can have undesired properties.

Polymer modified bitumen roofing cover has been discussed previously in the section on sloped roofs. Bitumen roofing sheets can be used for flat roofs as well. The takeaway message is that bitumen is a fossil fuel-based roof cover that contains cancerogenic Polyaromatic hydrocarbons (PAHs), biocides such as mecoprop and other undesired residues or additives that can leach into the environment during the use and at the end-of-life.

Built-up Roofing (BUR) construction is a multilayer roofing structure comprised of multiple layers fibreglass or felt coated with asphalt or tar and the top layer is coated with gravel to protect the roof from sunlight and other environ-mental effects. It is a proven roofing system that is durable, easy to maintain, is resistant to water and can last for up to 30 years with proper care. Asphalt or tar contains Polyaromatic hydrocarbons (PAHs) that may runoff into the environment with rain. This roofing system requires much more material than previously discussed membrane covers, it is more expensive and has a higher carbon footprint.

Green roofs are essentially a layer of soil with vegetation on top of the roof structure and separated by protective membranes. Green roofs can be either flat or slightly sloped. Green roofs are fashionable and are considered a sustainable building solution, as the roofing material is seemingly replaced with the layer of soil. But there is more to this than the layer of soil with vegetation, besides which, the typical functional elements in green roofs can be root barriers, filter layers, drainage membranes and water retention layers. All of these are typical made from polymer material. Some of the membranes are made from PVC, EPDM or modified bitumen that may have undesired hazardous chemicals and should be avoided, as some chemicals may be leached into the environment or be released at the end-of-life. Polyethylene or polypropylene based products should be preferred as these are considered safer plastics.

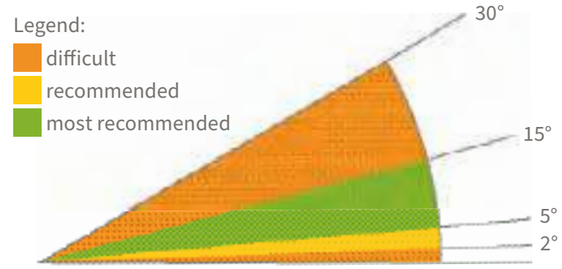


Figure 7: Illustration of slope angle consideration for the green roof. (Source: Auraplan)

Very eco-friendly looking green roof, but this is not a Hobbits´ home, there are a lot of modern materials inside.

Additionally, green roofs require a sturdier structural support, as the layer of soil and the amount of water that it may absorb weighs much more than other kinds of roof covers. Thus, green roof is not suitable as a replacement roof cover during the DIY renovation, unless the house has been designed to have a (heavy) green roof or is being redesigned to improve its structural strength to suit the green roof.

Green roof has good insulation properties, but it depends on thickness of the soil layer. Green roofs also can help counter the air pollution, contribute to improving air quality and reducing the urban heat island effect.

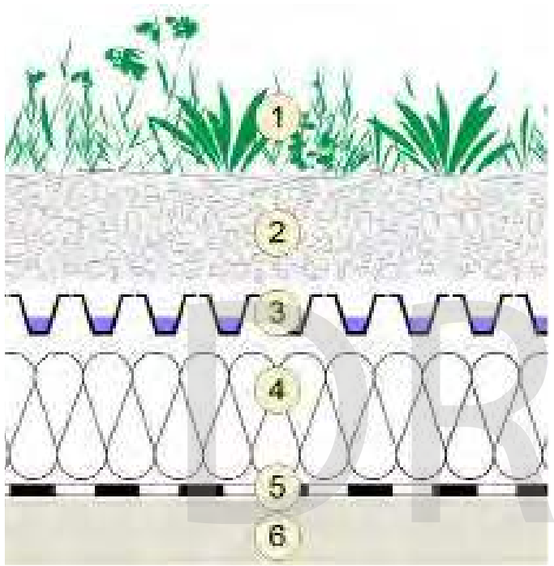


Figure 8:
Construction layers of a green roof
(Source: Auraplan)
1. Vegetation
2. Vegetation support/substrate layer
3. Filter- and Drainage layer
4. Insulation
5. Sealing
6. Sub construction

List of flat roof material
(green = good choice, yellow = okay, red = bad choice)

Material	Hazardous substances?	Circularity (can be recycled?)	climate impact	Durability	Costs
EPDM (Ethylene propylene diene monomer)					
PVC (polyvinyl chloride)					
TPO (thermoplastic polyolefin)					
Polymer modified bitumen					
Built-up roofing (BUR)					
Green roofs					

Of course, rating materials from good to bad can depend on many different factors (e. g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

Attention! Before buying a new roof cover, consult a specialist, who will be able to evaluate, which materials are the most suitable for your building situation. There are nuances such as slope angle, underlying construction and other specifics that should be taken into account, thus professional knowledge is necessary

The roof cover replacement should also be done by a skilled professional, as there are fine nuances involved in the work that requires skill and experience. It is in most cases cheaper to hire a specialist so that mistakes are avoided and durability and longevity of the roof is ensured.

3.2 WALLS FACADES, TERRACES

During a DIY construction or repair the choice of wall materials or facade cladding is often dictated by price (cost efficient vs expensive), local building traditions (considering local climate), legal requirements (energy efficiency) and trending design tendencies. Carbon footprint, circularity and chemical contents are also becoming important criteria for the choice of wall material. These criteria are important as walls, facades and terraces are a significant part of a house both in terms of mass (think about the climate footprint) and surface area (significant if we think about chemical leaching).

In this chapter we will discuss structural wall materials and exterior facing materials such as various types of cladding or structural material that may or may not need additional finishes, such as masonry walls and we will discuss terrace building options from the chemical hazard, circularity, and carbon footprint perspective.

Walls

Most common wall materials are clay bricks, silicate bricks or blocks, expanded clay blocks, concrete blocks, or poured concrete walls and some parts of structural support can be made of steel. Timber frame houses are a common decision also. These structural materials are relatively inert and will not be discussed from the chemical hazard perspective. Their carbon emissions profile (per mass unit) can differ quite a lot with wood being the best option with negative carbon footprint. In comparison, fired clay bricks or blocks have a relatively high footprint (steel is even higher), while concrete is somewhere in between. The mass of material used for construction should also be considered, thus fired-clay brick walls end up having the highest footprint. From the circularity perspective, at the end-of-life fired clay bricks can be reused as they normally survive demolition, while blocks do not. Timber can also be reused or at least used as fuel. Less common, but nonetheless, interesting and environmentally friendly are clay-based wall constructions, such as cob, straw bale, wattle and daub and adobe brick walls.

List of wall material
(green = good choice, yellow = okay, red = bad choice)

Material	Hazardous substances?	Circularity (can be recycled?)	climate impact	Durability	Costs
Fired clay bricks					
Poroton bricks					
Silicate bricks/ blocks					
Aerated concrete blocks					
Expanded clay blocks					
Concrete					
Wooden framework					
Unfired clay-based (e. g. cob, adobe bricks or other)					
Straw-bale					

Of course, rating materials from good to bad can depend on many different factors (e. g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

Metal cladding such as steel and aluminum are durable and relatively long lived. The carbon footprint of aluminum is high, of steel it is lower. Steel does not emit toxic chemicals, nor does aluminum. Both materials are recycled at the end of their service life.

Stoneware cladding such as slate, limestone or igneous rock slabs are very long-lived. Their carbon footprint is quite small only resulting from quarrying, cutting or other kinds of processing and transportation. No hazardous materials are produced at the end-of-life.

Ceramic cladding also a relatively long-lived material with a higher carbon footprint resulting from the firing of ceramic material. Hazardous materials are not usually contained in ceramic cladding.

Concrete cladding. Lightweight concrete element such as fibre cement boards or other types can be used for facade cladding. The material properties vary according to their type, but fibre cement boards for example are relatively durable although lightweight.

Wood facades. Wood is considered a sustainable material since it has a negative carbon footprint (carbon storage). However, the wood is most often chemically treated with preservatives (biocides) that may be persistent and toxic and may leach into the environment. An alternative for wood preservatives could be heat treated wood or charred wood that is not attractive to microorganisms, thus it may not need preservation or coating.

PVC cladding. PVC is one of the most toxic plastics that is well known to contain toxic additives such as phthalates many of which have endocrine disrupting properties. There may be other hazardous components as well, such as chlorinated paraffins or other additives. During the manufacture and at the end-of-life of PVC highly toxic chemicals dioxins and PCBs may form. PVC can be recycled but not always is.

Rendered facades. There are numerous types of renders available: lime-based, cement-based, polymer (such as acrylic) based, monocouche render, stucco render, silicone or even clay render. Render products are usually relatively tox-free, as they are mineral based. Some renders contain synthetic polymers to increase their performance, but from the circularity perspective it is not sustainable. Renders are then usually coated with paints. Paint categories are discussed in chapter 3.4.

Facades

Facades whose exterior is made of steel sheets or are natural mineral materials based such as stoneware cladding, ceramic cladding or concrete cladding typically have no chemical hazards, as do the masonry exteriors, or bare poured concrete walls. More concerning is chemically treated wooden facades as well as synthetic PVC cladding and some coatings used for plastered walls (discussed in chapter 3.4.).

List of facade material (green = good choice, yellow = okay, red = bad choice)

Material	Hazardous substances?	Circularity (can be recycled?)	climate impact	Durability	Costs
Steel cladding					
Aluminium cladding					
Stoneware cladding					
Ceramic cladding					
Concrete cladding					
PVC cladding					
Rendered facades					
Treated wood facades					
Heat treated wood facades					

Of course, rating materials from good to bad can depend on many different factors (e.g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

Attention! Before considering buying facades materials always have a plan ready regarding insulation, windproofing, other wall elements. It is best to consult a specialist, who will be able to evaluate, which materials are the most suitable for your building situation. This is important, as different materials have different water and windproofing qualities, different air and moisture diffusion characteristics, thermal properties.

A professional will be able to consider all of these characteristics for facades in relation to wall material, insulation, engineering materials and should provide the most rational solution, so that building walls are not under- or overengineered, thus saving costs and avoiding problems. It is in most cases cheaper to hire a specialist so that mistakes are avoided and durability and longevity of the building is ensured.

Terraces, conservatories, orangeries

The main concerns related to terrace construction is use of wood preservatives. It is possible to avoid the at least partially by choosing heat treated wood or certain rot-resistant wood species. However, horizontal structures that are exposed to rain, such as floors or other elements subject to water puddling will still need preserving. Another option would be to use a different material, such as PVC, or WPC (wood plastic composite) boards. However, PVC boards have undesirable constituents such as phthalates, chlorinated paraffins or other additives and it is best to avoid them. While WPC boards are typically made from recycled materials and can have different kinds of plastics (containing different kinds of additives) in the composition, thus it also not a tox-free option.

A good alternative could be fibre cement boards. These are sometimes manufactured to imitate wood (with textures and colours). Fibre cement boards are both durable, lightweight, and environmentally friendly.

List of terrace material (green = good choice, yellow = okay, red = bad choice)

Material	Hazardous substances?	Circularity (can be recycled?)	climate impact	Durability	Costs
Treated wood boards					
PVC boards					
Wood-plastic composite (WPC)					
Fibre cement boards					

Of course, rating materials from good to bad can depend on many different factors (e.g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

The roof and walls of conservatories/ orangeries need to be clear. In the past glass was exclusively used for these structures. Although glass structures are aesthetically pleasing but glass can easily break, and it has poor thermal properties. Additionally, glass structures are much more expensive as their set-up is labour intensive, they require framing and sealants may need to be used to attach each glass plate.

Nowadays, clear plastics such as polycarbonate or acrylic are often used, and the roofing sheets made of channelled polycarbonate or corrugated acrylic are readily available. Polycarbonate sheets are durable and relatively long-lived (20–30 years) and provides some thermal protection, but polycarbonate plastic is known to have bisphenol A (an endocrine disruptor) residues, thus acrylic sheets would be a safer option. The downside is their shorter lifespan (up to 10 years).

List of conservatory and orangeries material (green = good choice, yellow = okay, red = bad choice)

Material	Hazardous substances?	Circularity (can be recycled?)	climate impact	Durability	Costs
Glass					
Channelled polycarbonate					
Corrugated acrylic					

Of course, rating materials from good to bad can depend on many different factors (e.g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

3.3 ENGINEERING MATERIALS

In residential buildings various engineering materials are used to protect the indoor environment and the building substructure from the physical and environmental effects. Special wind proofing materials in combination with vapour barriers protect the building's insulation layer from the entry of cold or warm air, thus improving the efficiency of insulation and preventing the condensation (formation of water droplets) in the building substructure, which could lower the efficiency of insulation and cause damage over time. These materials are used in construction of walls and roof and today the most popular materials to provide these functions are synthetic films made from polymer materials.

Wind proofing and breathable membranes:
Wind proofing materials are essential components in walls and roofs, especially in areas where humidity levels fluctuate. Microporous polymeric films, like expanded polytetrafluoroethylene (ePTFE) or microporous polypropylene are used as breathable membranes. These films have microscopic pores that allow water vapor to escape while preventing the penetration of liquid water. These properties are necessary to ensure building breathability and good air quality (see chapter 4.2). Some breathable membranes are also coated with hydrophobic substances, such as silicone-based compounds or fluoropolymers, to repel water and maintain breathability.

Vapor Barrier Membranes: Vapor barrier membranes, commonly used in construction, are made of high-density polyethylene (HDPE) or low-density polyethylene (LDPE). These polyethylene materials effectively block the transmission of moisture vapor, ensuring a tight seal against water infiltration. Typically, they are laid down on the interior side of insulation to prevent moisture condensation from inside.

Waterproofing films and/or anticondensation films:
These are typically used as roof underlays to prevent water seepage into the underlying structure. These are particularly useful for metal roofs, where condensate is actively forming. Waterproofing films are typically made from polypropylene or polyethylene.

Thermal insulation. Various kinds of materials have thermal insulation properties and can be used for buildings. There are many plant-based material options available such as wood fibre, cellulose fibre insulation, flax fibre (jute), hemp or flax shives, straw, cork, or other materials. These can be obtained loose or manufactured into insulation sheets. There are numerous mineral-based options such as rock wool, glass wool, vermiculite/ perlite and expanded clay. Still there are synthetic types of insulation, such as expanded polystyrene (EPS or Styrofoam), extruded polystyrene foam (XPS), polyurethane foam and others. Some insulation materials are with added reflective foils that helps to improve their properties. The abovementioned materials differ in their insulation efficiency, how it changes over time and the price. But in some cases, insulation may not be needed at all, for example in warmer areas or if the building has thick walls.

Plant based insulation. In general, renewable plant-based materials will have a low to negative carbon footprint. Hazardous chemicals are absent in the raw materials, but flame retardants can be added during the manufacture to lower their combustibility. Thus, commercially available cellulose wool, flax or hemp insulation will likely have flame retardant additives, even though, the raw material is hazardous materials free.

During the construction, care should be taken to isolate plant material-based insulation with the appropriate use of diffusion films and vapour barriers to prevent contact with water that could initiate their degradation. At the end of service life, plant-based materials can be composted leaving no residue behind, provided there are no chemical additives present. Cellulose fibre on the other hand is often applied as wet paste and preservatives are added to it to prevent bacterial degradation. One of the practical downsides is that these natural materials may be browsed or inhabited by mice and other animals that may degrade insulation efficiency over time.

Mineral-based insulation. Stone wool and fibre glass wool have slightly better thermal conductivity than renewable materials such as hemp or wood fibre insulation materials. They both offer very high durability, resistance to decay and infestation by pests. Both glass and stone wool are non-combustible thus flame retardants are not added during their manufacture and no other chemical ingredients are needed. The production of stone/ glass wool is an energy intensive process.

Expanded clay, vermiculite, perlite, or other loose material is most used to insulate floors and slabs, but not so often for walls. While vermiculite is a naturally occurring mineral material, expanded clay and perlite are made by heating clay granules to produce expanded clay and volcanic rock to produce perlite. Temperatures of over 1000°C are used. These materials have an excellent thermal and acoustic insulation properties. These materials are resistant to fire, fungi, mould and the effects of insects or rodents. Vermiculite has a low carbon footprint while high heat is needed to produce expanded clay or perlite, thus their footprint is higher. At the end of life these materials do not degrade and can be reused again, provided they are properly collected.

Synthetic insulation. Both polystyrene and polyurethane foam are good insulators and are very popular materials. The downside is the flame-retardant additives present in these materials, as they are usually quite flammable. Additionally, their manufacture processes are polluting, and these materials have a significant carbon footprint. At the end of life both materials can be recycled

List of insulation material (green = good choice, yellow = okay, red = bad choice)

Material	Hazardous substances?	Circularity (can be recycled?)	climate impact	Durability	Costs
Cellulose (wood or paper wool)					
Wood fibre boards					
Flax boards					
Hemp wool					
Hempcrete					
Straw					
Mineral wool					
Fibre-glass					
Expanded clay					
Perlite					
Vermiculite					
Polystyrene (EPS and XPS)					
Polyurethane (PU) foam					

Of course, rating materials from good to bad can depend on many different factors (e.g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

Attention! For insulation, wind proofing, consult a specialist, who will be able to evaluate, which materials are the most suitable for your building situation. This important, as different materials have different water and wind proofing qualities, different air and moisture diffusion characteristics, thermal properties.

A professional will be able to suitable engineering materials in relation to wall material, so that building walls are not under- or overengineered, thus saving costs and avoiding problems. It is in most cases cheaper to hire a specialist so that mistakes are avoided, and durability and longevity of the building is ensured.

3.4 Coatings, Adhesives, Sealants

Numerous compositions of coatings, adhesives or sealants are available today, each tailored for specific situations. Some products are suited for harsh conditions where surfaces are affected by environmental factors, corrosion, or mechanical stresses. Meeting these technical demands often involves complex mixtures of chemicals, some of which can be hazardous. The major concerns related to coatings, adhesives and sealants involve emissions of Volatile Organic Compounds (VOCs (more information about VOCs s. chapter 4.2)) from solvent-based products, leaching of preservatives and other harmful additives. Safer products, water and polymer based, are available and may have only a very low number of harmful constituents.

Coatings: Choice of outdoor coating depends on the surface they are applied and their exposure to various conditions. Choosing a coating product can become a headache therefore it is best to ask an expert. Most popular exterior paint types shall be discussed highlighting their advantages and drawbacks (see chapter 2.2. for more about interior paints).

Water based low-VOC paints: Water-based paints, such as acrylic, latex, waterborne enamel, and emulsion paints, are widely used and easily accessible. These paints typically consist of binders that are polymers like acrylic, vinyl acrylic, and PVA providing cohesion; pigments; solvents-primarily water with small amounts of other organic solvents facilitating applicability and drying; fillers like calcium carbonate enhancing texture and coverage; and additives such as surfactants, thickeners, stabilizers, and preservatives that may pose environmental risks. Only high-quality exterior water-based paints should be chosen that have improved durability and can last for a long time. Additionally, at the end of service-life polymer paints may generate microplastics.

Solvent-based paints ("oil paints") are petroleum (or other solvent) based paints that are well suited for outdoor conditions as the coating layer has good durability and longer lifespan. The downside is the associated occupation risk due to the high amount of solvent in the product. Additionally, their application should be carefully thought trough as the paint layer is impermeable to air or water vapour and can cause problems in the underlying construction.

Alkyd paints or alkyd enamel paints are a derivative or "an upgrade" of oil-based paints and are made of alkyd resins, solvents, and other additives. Alkyd paints are known for their good durability and versatility, but the disadvantage is the high levels of VOCs present, some of which may be cancerogenic, cause respiratory irritation, headaches, or other adverse health effects.

Natural oil-based paints: One of more typical options is linseed oil paint. It can last 15 years or more without maintenance. It is resistant to flaking and peeling and is environmentally friendly. Additionally, there is no strong odour, it dries within 24–48 hours, and is cost-effective. Drying agents and natural pigments can be added to the compositions by some manufacturers, without the use of solvents, binders, or synthetic emulsifiers. Some manufactures add solvents to the products to ease applicability, but due to occupational risk related to VOC emissions solvent containing options should be avoided.

DIY paints:
There are many DIY paint guides available. Pigments and other paint ingredients can be bought separately in powder form and mixed just before use. In this way, the use of preservatives could be avoided, as there is not enough time for microorganisms to start degradation of the liquid mixture.

Wood preservatives are in some cases unnecessarily applied onto wooden surfaces instead of paints without paying attention to their biocide content and environmental risks they pose. For facades they can be avoided by choosing alternative options such as heat-treated wood or charred wood.

Varnishes are coatings used on surfaces like wood or plaster to add a glossy finish and shield against water and dirt. They enhance durability and prolong the material's lifespan. Varnishes are based on plant oils, waxes, and tree resins (such as conifer-derived rosin), while synthetic options are polymer-based. From an environmental standpoint it is advisable to choose VOC-free or low VOC products. These include natural oils used as varnishes or water-based acrylic varnishes. It is worth keeping in mind that nowadays the performance of water-based coatings may be just as good as solvent based and fully suitable for exterior uses in DIY construction or repair works.

List of paints
(green = good choice, yellow = okay, red = bad choice)

Material	Hazardous chemicals	Circularity (can be recycled?) Yes/No	CO_2 footprint	Durability
Paints				
Water-based low/zero VOC paints				Varies
Solvent-based ("oil paints")				
Natural oil-based paints				
Alkyd enamel paints				
Wood preservatives				
Varnishes				
Plant oils as varnishes				
Solvent based plant oil varnishes				
Oil/ wax/resin-based varnishes (solvent)				
Water-based acrylic				

Of course, rating materials from good to bad can depend on many different factors (e.g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

Adhesives and sealants

Similarly, to coatings and paints, various types and categories of adhesive products exist suited for different applications and different conditions. It is easy to get confused which products to choose, what are the safest and most nature-friendly options suitable for DIY application. Among the most popular types of adhesives are: acrylic, cyanoacrylate, PVA, polyurethane, epoxy resins but there are many more.

Sealant products typically used in the interfaces between different materials to make joints or to fill the gaps between construction elements. Some sealants are designed to provide a protective or impermeable barrier such as those needed between window frames and window glass. Sealants need to be flexible, durable and maintain their sealing properties throughout their lifetime. Sealants can have similar chemistries to adhesives, but there may be different functional components (additives. Acrylic, polyurethane (PU), silicone, butyl rubber, water-based latex sealant types are discussed in more details below.

Acrylic adhesives are water-based acrylate polymer emulsions with adhesive properties. Acrylic glues can bond to a wide range of substrates, as they form strong bonds that are durable and resistant to environmental effects. They are often used to bind floor covers and ceramic tiles. Acrylic adhesives are manufactured into various kinds of products including sealants and caulk. When used, acrylic adhesives emit vapours of acrylic acid and related chemicals that may cause respiratory irritation and the components may sensitize skin when in contact. Some products may be solvent based, thus chemical safety should always be kept in mind.

Cyanoacrylate adhesives are also known as superglues. They are related to acrylic and are most often used for repair works, especially of smaller components and are often needed for DIY applications. Cyanoacrylate glues form an extremely strong and long-lasting bond. However, it is not a great structural adhesive, and it is not typically used in construction. Cyanoacrylates have more aggressive chemicals compared to acrylics, that may cause skin, eye, and respiratory irritation.

Epoxy resin is a two-component adhesive comprising of the resin and the hardener. When the 2 components are mixed in equal proportion chemical reaction starts to occur and the resin starts to harden until it solidifies. Epoxies form an exceptionally durable and reliable bond and are resistant to environmental factors. This resin adheres to a wide range of materials, including metals, plastics, wood, ceramics, glass, and composites. When working with epoxy resins, among the concerns are the VOCs and the Bisphenol A (BPA) residue that is present in the resin. BPA is an endocrine disrupting and toxic to reproduction chemical that may leach into the environment over time.

Polyvinyl acetate (PVA) glues, commonly known as white glue, are widely used type of adhesive with a water-based formulation. Most commonly PVA is used for wood and small crafts and is present in almost every household, as it is non-toxic, although some products may contain additives, such as preservatives, that may have undesired hazards. Typically, plain PVA is not used for outdoor applications. Variations of PVA adhesives exist, however, where PVA is cross-linked with other polymers to give it certain properties like water and weathering resistance.

Polyurethane (PU) glue is yellow and foamy during curing. It adheres well to various materials like wood, paper, metal, glass, and plastic. It sets quickly to form a strong, water-resistant bond. While it can fill holes and cracks due to its slight expansion, it's messy and can stain surfaces. It's highly durable and waterproof, making it ideal for outdoor projects. Additionally some sealants are polyurethane based and can be used where high performance is required. Polyurethane foam sprays are often be used to seal gaps in constructions.In terms of chemical safety, polyurethanes contain isocyanates that are toxic, skin, eye, respiratory tract irritant. Some isocyanate compounds are suspected cancerogens. During application and curing PU also release VOCs, but once cured adhesive is chemically inert and safe. PU has a significant ecological footprint as the industrial processes to manufacture it cause pollution.

PU glues are not recommended for DIY applications unless suitable protective measures like gloves and good ventilation or even respiratory protection is ensured.

Silicone sealants are based on siloxane polymers that have water repellent properties, an excellent resistance to environmental effects (heat-cold, UV) and are chemically inert and long lived. However, they are not necessarily tox-free as it is often claimed. While acetic acid-based silicones are more friendly to human health, other options may have cancerogenic components. Silicone products designed for wet/ damp environments will most likely have antimicrobial component that are hazardous to human health and the environment. Additionally, some siloxane compounds are seen as emerging risk, as some have been found to be persistent in the environment.

Butyl rubber sealants are made of synthetic rubber. They are waterproof and have low gas permeability. Butyl rubber has strong adhesive properties and is utilized for applications like filling gaps for roof flashings, chimneys, and gutter connections as well as windows, masonry joints and other interfaces. However, as they are solvent-based, workers and nearby individuals can be exposed to harmful chemicals. Stoddard solvent, which is typically used for butyl rubber sealant is carcinogenic and mutagenic.

Water-based latex sealants are widely used for residential construction and DIY applications. They are easy to apple on various surfaces, easy to clean-up and are cost-effective. Latex sealants are mostly suited for indoor applications, but there are products designed for exterior uses. Latex sealants have a low VOC content, are practically odour free. Latex sealants are especially suited for sealing narrow joints/small gaps where there is only minimal mechanical movement. Water based latex is one of the human health and environmentally friendliest options.

List of adhesives, sealants (green = good choice, yellow = okay, red = bad choice)

Material	Hazardous chemicals	Circularity (can be recycled?)	Climate impact
Adhesives, sealants			
Acrylic adhesives/sealants			
Cyanoacrylate			
Epoxy resin			
PVA (polyvinyl acetate)			
PU (polyurethane)			
Silicone sealants			
Butyl rubber sealants			
Water-based latex sealants			

Of course, rating materials from good to bad can depend on many different factors (e.g. manufacturer, treatment, origin, etc.), so the weighting can also vary. We focus on conventional products.

In most cases, adhesives and sealants are used by professionals during the construction or repair works. For the DIY application it is advisable to always consult a specialist on the type of product suitable for the required application. There are nuances regarding to material suitability (certain adhesives/ sealants suitable for only certain surfaces), as well as UV, moisture resistance, mechanical stresses and other factors.

Whichever adhesive or sealant product is chosen, it is advisable to check the product label or request for a safety data sheet (SDS) as some products may contain undesireable additives such as phthalate plasticisers.

CHAPTER 4: ENERGY EFFICIENCY AND INDOOR AIR QUALITY

4.1 ENERGY EFFICIENCY

The energy efficiency of existing buildings is a decisive factor in achieving climate protection targets. For you as a do-it-yourselfer, it is important to know that minor or major renovation measures on walls, doors and windows can have an impact on the energy efficiency of the building. In addition, national laws may require an energetic modernisation because of a minor renovation measure. According to the German Building Energy Act, building parts that are renovated in more than 10% of the area must fulfil minimum energy efficiency requirements in their entirety after the renovation.

Calculating the energy balance is a complex matter. Measures to improve energy efficiency range from sealing and insulation to building design (e.g. changing window sizes or roof overhangs). It is highly recommended to consult an energy consultant and qualified architects.

When planning and selecting energetic modernisation measures, it should be noted that there may be conflicts between achieving energy efficiency targets and avoiding pollutants. There is a wide range of insulation materials, air sealing membranes etc. with different chemical contents. You find further information in the chapters (engineering materials and thermal insulation).

Also, the airtight sealing of rooms reduces the supply of fresh air and thus increases the residence time of volatile organic components in the interior.

Energy Efficiency

Consult a professional
Legal acts might set obligations for minimum energetic requirements of your renovated home.

The calculation of an energy-balance is a complex matter.

A high energy efficiency is of utmost importance for the sustainable transformation.

A variety of measures exist with numerous interlinked advantages and disadvantages related to chemical content, energetic performance, costs, health protection, circularity.

4.2 INDOOR AIR QUALITY

Unintentional heat loss through uncontrolled air-exchange is to be minimised. Nevertheless, regular ventilation is important to maintain a good air quality. Ventilation takes both moisture and pollutants outdoors and brings in oxygen. Hence it is important to think about a ventilation concept whenever renovation activities are being carried out that aim to increase the energy efficiency by sealing the room (e.g. changing windows). Today various systems are available that control the air exchange through automated ventilation, optimizing the air exchange by minimizing heat losses. Such systems can be an adequate help. However, a manual regular cross ventilation (opening all windows widely for a short time) can also be an appropriate approach. Check the options and talk to an expert when doing your renovation.

4.2.1 VOCs

VOCs (volatile organic compounds) are chemical compounds, that enter the indoor air through outgassing from various construction materials (paints, glues, sealants etc.) but also from consumer goods. A high concentration of VOCs can lead to complaints such as breathing problems, dizziness and headaches or irritation of the eyes and nose. Some VOCs are considered carcinogenic or mutagenic. Choosing construction materials without VOCs is thus the most effective measure to maintain a healthy indoor environment. Find a list of the most common VOCs in the box.

COMMON VOCs

Make sure to avoid:

Benzene: Found in paints, adhesives, and gasoline. Can cause cancer

Toluene: Present in paints, varnishes, and some adhesives. Can cause neurological effects

Xylene: Used in various products, including paints, adhesives, and cleaning agents. Can cause respiratory and neurological symptoms.

Formaldehyde: Often found in adhesives and wood-based materials. Is considered as possibly carcinogenic.

Ethylene Glycol: Often found in antifreeze and some paints. Can be toxic to the central nervous system, kidneys, and heart.

Acetone: Found in paint thinner, nail polish remover, and certain adhesives.
Can cause respiratory irritation.

1,4-Dichlorobenzene: Used in mothballs, deodorizers, and some adhesives.
Can harm the liver and kidneys.

Methanol: Present in certain paints, varnishes, and cleaning products. Can cause irritation to the eyes, skin, and respiratory tract.

FORMALDEHYDE: The omnipresent toxin of the 80s and 90s, do you remember?
In the 1990s, formaldehyde gained sad fame among the harmful and probably carcinogenic VOCs. It was practically everywhere: in the corpus of kitchen or other furniture, in wood fibre boards, floor coverings consisting of several glued layers. Formaldehyde was considered an invisible danger in the home or workplace. The indoor lily (Chlorophytum elatium), which was said to be able to bind formaldehyde effectively, was discussed as an effective antidote.

Formaldehyde is still in use today, provided that strict limits are observed. Since then, the use of glued materials in interior spaces has not decreased.

4.2.2 Preventing mould

Mould is a major health hazard. The formation of mould indoors should therefore be avoided by all means. Mould spores only need moisture and a breeding ground consisting of organic components. Wallpaper or petroleum-based paints are therefore a potential breeding ground for mould. Areas that cool down at low outside temperatures are particularly susceptible to mould because the ambient moisture from the warm interior condenses there. As a rule of thumb, condensation is to be expected when a building component cools down to 12 °C or less. To prevent mould, the indoor humidity must therefore be limited by means of a sensible ventilation concept (see chapter 4.2) and the temperature of the walls, window frames etc. must be kept at a sufficient level through adequate thermal insulation. For you as a do-it-yourselfer, it is important to note that replacing windows (sealing air vents) can lead to an increased risk of mould growth if there is insufficient wall insulation and/or ventilation concept.

Mould growth can also occur in the internal insulating layers of the wall. Air-tide membranes and vapour barriers are used to prevent this. The membranes should be selected and installed by a specialist. We strongly recommend that you consult an expert before insulating your home. During the consultation, also discuss the chemical components of the membranes and make sure that, in addition to functionality, attention is also paid to the absence of hazardous substances.

CHAPTER 5: CIRCULARITY, WASTE MANAGEMENT AND RECYCLING

5.1 CIRCULARITY AS A CONCEPT FOR MINIMIZING RENOVATION WASTE

The concept of circularity, or the circular economy, revolves around creating a closed-loop system wherein resources are used, recycled, and reused to the maximum extent possible, minimizing waste and reducing the need for new resources. Here's how circularity can be integrated into minimizing renovation waste:

ELEMENTS OF THE CONCEPT	PRINCIPLE	APPLICATION
1. Designing for Deconstruction and Reuse	Design spaces and select materials in a way that allows for easy disassembly and reuse.	Use screws instead of glue for joinery, select modular components, and employ construction methods that allow for easy dismantling.
2. Material Reutilization	Implement strategies to reuse materials, either within the same application or in a different context.	Salvage materials like bricks, wood, glass, and fixtures from the renovation site for reuse either in the same project or different ones.
3. Extending Lifecycles	Enhance the longevity of materials and components to minimize frequency of replacement and thereby reduce waste.	Choose durable materials and create designs that are timeless and adaptable to avoid early obsolescence.
4. Regenerative Resources	Opt for materials that are renewable and have a lower environmental impact.	Utilize materials like recycled glass, or reclaimed wood which have low ecological footprints and can be replenished.
5. Maintenance-Friendly Designs	Create designs that are easy to maintain and repair, thus extending their lifecycle and minimizing waste.	Create designs that are modular, durable, simple and safe. Ensure that components requiring maintenance are easily accessible and use standard and interchangeable parts wherever possible.
6. Waste as a Resource	View waste material not as trash, but as a resource that can be harnessed for other purposes.	Utilize construction debris (which should not contain hazardous substances, plastics or any other harmful material) for landscaping or as a base for pathways and repurpose old fixtures and fittings.
7. Sustainable Purchase	Source materials that have been produced in a circular manner and can be returned into the loop after use.	Choose products from manufacturers who have taken-back programs or who utilize recycled materials in production.
8. Collaboration with Circularity Partners	Engage with suppliers, manufacturers, and disposal entities that adhere to circular principles.	Work with recycling facilities that can process waste materials or suppliers that offer refurbished items.
9. Knowledge Sharing	Share your knowledge and experience with your friends, relatives, neighbours	Document the process of employing circularity principles in your renovation and share knowledge with your friends, relatives, and neighbours.
10. Enabling Technology	Leverage technology to optimize resource usage and facilitate circularity.	Implement digital platforms for material tracking, trading, or managing resource flows to ensure optimal utilization.

By embedding circularity into refurbishment processes, we are creating a resilient and sustainable approach that not only minimises waste but also makes the most of available resources, promoting both environmental and economic Benefits of Circularity in the **Context of Renovation Waste:**

- Minimize Landfill Waste: By reusing and recycling materials, less waste ends up in landfills other end-of-life-treatments.
- Resource Efficiency: Ensuring resources are utilized optimally and waste is minimized.
- Cost-Effective: Reusing materials or choosing reclaimed items can be cost-efficient.
- Sustainability: Enhancing environmental sustainability by reducing resource consumption and waste.
- Innovation: Encouraging innovative design and construction practices that enable circularity.

5.2 Strategies for Minimizing Renovation Waste

Plan Meticulously

- Accurately measure and order materials to avoid excess.
- Create a detailed inventory to monitor material usage and avoid over-purchasing.

Preserve and Reuse

- Dismantle instead of demolishing: Carefully remove materials to enable reuse.
- Salvage materials like doors, windows, fixtures for reuse within the project.

Donation

- Offer usable items and materials to non-profits, schools, or community centres.
- Utilize online platforms to give away items to local communities.

Material Optimization

- Use designs that allow for standard material sizes to minimize off-cuts.
- Opt for materials/products that have a take-back program with suppliers.

5.3 Tips for Separating and Recycling Waste Material

Segregate at Source

- Set up designated bins for different waste types (metal, glass, wood, etc.) on site.
- Ensure clear labelling and education for workers on waste segregation practices.

Dispose Safely

- Identify and separate hazardous waste, ensuring its safe and compliant disposal.
- Engage certified disposers for hazardous waste like asbestos or lead-based paint.
- In general, find out about the disposal of construction or renovation waste (wallpaper, paints etc.) in your city.

Recycle Responsibly

- Collaborate with local recycling centres and understand their material requirements.
- Ensure materials are clean and separated as per recycling facility standards.

Material Optimization

- Keep records of the waste generated, recycled, and disposed of for accountability and reporting.

5.4 Ideas for Upcycling Waste into Functional or Decorative Items

Furniture Creation

- Transform wooden pallets or old doors into tables, benches, or shelving.
- Use scrap metal or pipes to create unique lighting fixtures or frames.

Artistic Decor

- Create wall art from leftover tiles, wood pieces, or glass fragments.
- Develop mosaics from broken tiles or glass for decorative surfaces or pathways.

Garden Enhancements

- Use old bricks or stones to create garden beds, paths, or retaining walls.
- Upcycle wooden planks or metal sheets into planters or garden décor.

Functional Items

- Convert leftover materials into functional items like coat racks, storage bins, or organizers.
- Repurpose glass or ceramics into containers, vases, or candle holders.

Community Projects

- Collaborate with local artists, schools, or community centres for using waste in public art or utility projects.
- Initiate a community exchange or marketplace for materials that can be upcycled.

By adopting meticulous planning, adhering to systematic waste management, and recycling principles, and embracing creative upcycling practices, renovation projects can significantly minimize their environmental impact. Embedding these principles not only promotes sustainability but also adds a unique and personalized touch to the renovated space, enhancing its aesthetic and functional value.

5.5 DOs AND DON'TS OF UPCYCLING AND DOWNCYCLING

Both upcycling and downcycling have their own challenges and opportunities. Upcycling, the process of transforming waste materials into products of higher quality or value, is generally considered to be more environmentally beneficial because it maintains or enhances the value of the material.

Downcycling, on the other hand, involves the recycling of materials into products of lower quality or value, often resulting in a loss of material integrity.

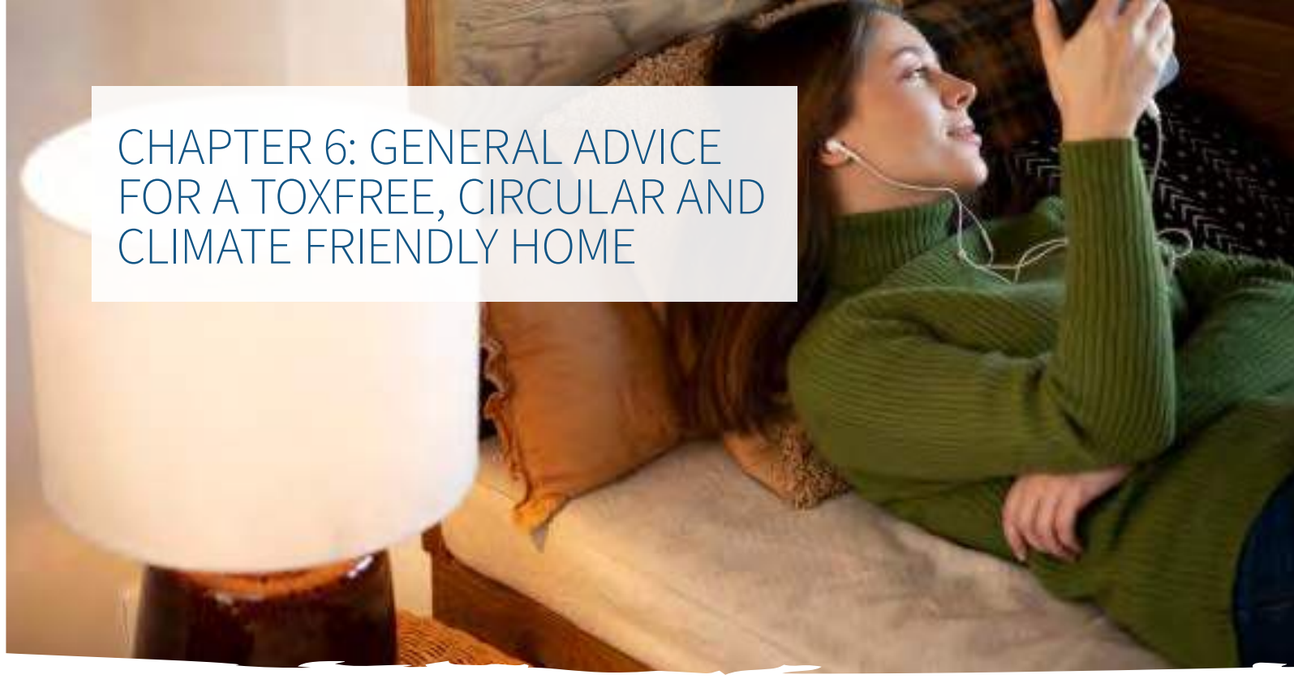
Understanding how to manage these processes can lead to more sustainable and responsible practices in any refurbishment or construction project. These practices not only help to minimise waste, but also make a positive contribution to the environment and the community.

Upcycling

DOs	DON'Ts
Be Creative: Do explore various possibilities and think outside the box when it comes to reusing materials in a new way.	**Ignore Sustainability:** Don't disregard the environmental aspect – consider the environmental impact of any added materials or processes.
Safety First: Do ensure that the materials being upcycled are safe to use, especially in a new context (check for stability, no sharp edges, etc.).	**Neglect Aesthetics:** Don't compromise on aesthetics. Ensure the upcycled item complements your space and style.
Maintain Quality: Do prioritize maintaining or even enhancing the quality of an item when upcycling it.	**Overlook Functionality:** Don't focus solely on form – ensure the upcycled item has practical utility and durability.
Embrace Uniqueness: Do cherish the uniqueness of upcycled items and leverage them as conversation starters or focal points in decor.	**Force Fit:** Don't force an item into a role that it's not suited for just for the sake of upcycling.
	Underestimate Time and Cost: Don't forget that upcycling can sometimes be time-consuming and potentially costly depending on the project.

Downcycling

DOs	DON'Ts
Research Opportunities: Do find out about various ways materials can be downcycled and what possibilities exist for your waste.	**Ignore Quality:** Don't neglect the quality of resultant materials after downcycling – they should still be safe and functional.
Collaborate: Do partner with organizations or facilities that can use your downcycled materials.	**Forget the End-Use:** Don't downcycle materials without considering their end-use and ensuring it's beneficial.
Separate Materials: Do segregate materials effectively to ensure they can be downcycled efficiently.	**Bypass Regular Checks:** Don't forget to conduct regular audits to ensure downcycling is being executed effectively and sustainably.
Prioritize Safety: Do make sure that downcycling processes and resultant materials are safe and comply with regulations.	**Overlook Transportation Impact:** Don't forget to factor in the environmental impact of transporting materials for downcycling.
Record and Analyse: Do keep track of downcycling processes to analyse their environmental and financial impact.	**Undervalue Communication:** Don't neglect to communicate about your downcycling efforts, as it may inspire others and enhance your social responsibility image.



CHAPTER 6: GENERAL ADVICE FOR A TOXFREE, CIRCULAR AND CLIMATE FRIENDLY HOME

6.1 ECOLABELS

Certifications and labels can be used to indicate the sustainability of a building or material. However, their sheer number has grown to almost unmanageable proportions. The spectrum includes labels from independent institutions, labels from voluntary self-regulatory interest groups, and marketing or advertising-driven labels from the building materials industry.

Roughly speaking, manufacturer-independent environmental and eco-labels can be divided into three groups:

- Labels that evaluate materials based on their sustainable origin and production.
- Labels that also certify specific product characteristics.
- Labels that certify the sustainability of entire buildings

Product-Label	
EPD	**Environmental Product Declarations (EPDs)** are based on the life cycle assessment method according to ISO 14040/44 and the more specific standards ISO 14025 and EN 15804. EPDs can be understood as a kind of "fact sheet" of the declared product. They contain technical information, details of selected life cycle modules, corresponding environmental parameters, and, if applicable, test results for a detailed assessment. Environmental product declarations have a binding, generally valid basis; they are prepared by experts and independently verified – nevertheless, the manufacturer bears the responsibility for the EPDs. EPD International has developed or is still in the process of developing about 64 Product Category Rules (PCRs) for construction products. Product Category Rules (PCR) offer guidelines for life cycle assessments and EPD development in specific product categories. They determine the scope, functional unit, and environmental impact categories.
cradle to cradle	The **Cradle to Cradle** Certified Program enables companies to showcase their commitment to environmentally intelligent product design. This certification covers a wide range of products, including textiles, electronic devices, cleaning agents, construction materials, and furniture. The assessment is based on five key criteria: Material health, Reuse of materials (circular economy), Use of renewable energies, Responsible water usage, and social justice. The certification offers five levels: Basic, Bronze, Silver, Gold, and Platinum. The Cradle to Cradle Certified certificate is granted by the Cradle to Cradle Products Innovation Institute, headquartered in San Francisco, USA.
M1	The emission classification of building materials has encouraged the development and use of low-emission building materials, interior design products, and furniture since 1996. Rakennustieto Oy (RTS), Finland, oversees the rating process. The main committee of RTS, comprising representatives from the building product industry, builders, designers, authorities, and experts, guides and supervises these activities. It's a voluntary eco-labelling system designed for classifying materials, fixtures, and furniture used in both living and working spaces. In terms of criteria, the **M1 classification** establishes limits for emissions of volatile organic compounds (VOCs), formaldehyde, and ammonia while also assessing the acceptability of the product's odour.

Product-Label

Danish Indoor Climate Labelling (DICL) is a certification program that systematically tracks the emission of chemical compounds from building materials, furniture, and fixtures into indoor air. Established in 1993 under the initiative of the Danish housing minister, it has been consistently managed by the Danish Technological Institute. Products bearing the Indoor Climate Label undergo a comprehensive testing process that results in detailed documentation of the release of chemical compounds into indoor air, as well as an evaluation of the product's sensory attributes, ensuring they are within acceptable limits. Testing within DICL covers various product groups, including building materials, furniture, and indoor fixtures. The general labelling criteria encompass factors such as volatile organic compounds (VOCs), carcinogens, and formaldehyde, which are applicable to all product categories. Additionally, ceiling products must undergo testing for particle emissions. Crucially, products bearing the indoor climate label must not emit carcinogenic substances. The label itself is divided into three emission classes.

The **CE marking** is an indicator of a construction product's compliance with its stated performance and adherence to European standards, as regulated by the Construction Products Regulation (CPR) within the European Union. Harmonized European standards, developed by experts, provide the technical basis for assessing product performance and allowing manufacturers to use the CE marking. In cases where no harmonized standard exists, European technical assessments (ETAs) provide an alternative means to evaluate performance and secure the CE marking. For most construction products, CE marking is mandatory to facilitate their sale within the European Internal Market. For a select few, it is optional but can be pursued under specific guidelines. The fundamental requirements encompass mechanical strength, fire safety, health, environmental standards, accessibility, noise protection, energy efficiency, and the sustainable utilization of natural resources.

The Natureplus label is a private eco-label in accordance with ISO 14024. It certifies adherence to high-quality sustainability standards across all relevant areas. To ensure compliance, accredited laboratories and assessors conduct tests in alignment with internationally recognized standards. Notably, the Natureplus quality label for building products stands as the sole European environmental label founded upon rigorous scientific criteria across various fields. This label guarantees that key criteria, encompassing resource sustainability, clean and efficient production, and the preservation of environmental and health standards, are upheld.

Nordic Swan is an official eco-label for the Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden), established by the Nordic Council of Ministers in 1989. Each country has its own eco-labelling secretariat responsible for its activities. Nordic Swan operates as a voluntary eco-labelling program, covering 56 product areas, encompassing over 200 product types. Within the construction sector, there are seven group categories: new buildings, Renovation, Chemical building products, Construction and facade panels, mouldings, Floor coverings, Indoor paints and varnishes, and Windows and Exterior doors. The Nordic Ecolabel employs three criteria for its certified products: Chemicals, Climate, and Circularity.

The Blue Angel, launched by the German government in 1978, is an eco-labelling program. The Federal Environmental Agency (UBA) establishes the specialized criteria that products and services must meet to receive certification. The Blue Angel operates on a voluntary basis and covers various product categories, including paints, varnishes, panel-shaped materials, sealants, thermal insulation materials, floor coverings, flooring underlays, panels and doors, plasters, concrete products for outdoor flooring, wallpapers, and woodchip wall coverings. The certification is based on three criteria: Chemicals, Climate, and Circularity

The EU Ecolabel, also known as the Flower Certification, is a voluntary eco-labelling program introduced by the European Union (EU). It covers 24 product and service groups across 11 categories that are eligible for the EU Ecolabel. Among these, there are three product categories: Indoor and outdoor paints, Wood- and bamboo-based floor coverings, and Hard covering products. The certification process evaluates various aspects, including the origin of the materials, their chemical and biological properties, quality and quality criteria, composition, recyclability, and disposability. Additionally, the assessment encompasses ingredient analysis and the inspection of emissions of hazardous substances or substances that may pose health risks, such as plasticizers.

Material-Label

The Forest Stewardship Council (FSC) promotes the environmentally sound, socially advantageous, and economically sustainable management of forests. On the other hand, **the Programme for the Endorsement of Forest Certification Schemes (PEFC)** is an international non-profit, non-governmental organization with a dedicated mission to foster sustainable forest management (SFM) through independent third-party certification. PEFC operates throughout the supply chain, actively promoting sound forest practices and ensuring that timber and other forest products align with stringent environmental, social, and ethical standards. In the case of the PEFC "regional" variant, it guarantees that all materials originate entirely from the specified region and are 100 percent certified.

Building-Label

BREEAM, which stands for Building Research Establishment Environmental Assessment Method, is among the most widely adopted and recognized environmental assessment methods for both buildings and infrastructure projects. BREEAM serves as a comprehensive framework for evaluating the sustainability performance of buildings and offers a standardized approach to assess their environmental, social, and economic implications across their entire lifecycle. The compliance with BREEAM standards is validated by an independent third-party organization. The BREEAM certification system encompasses critical criteria, including energy efficiency, health and comfort, accessible transport, water usage and management, environmental impact of materials, waste reduction, and the influence on the surrounding environment. The results are classified into five categories for new buildings and six for existing ones, representing varying levels of excellence. In Germany, Austria, and Switzerland, TÜV Süd is responsible for awarding the BREEAM certification.

LEED, short for Leadership in Energy and Environmental Design, is a green building certification program established by the U.S. Green Building Council (USGBC) in 2000. LEED uses a point-based rating system, where buildings accumulate points by meeting specific sustainability criteria. This rating system encompasses various aspects of a building's design, construction, operation, and maintenance. Based on the number of points earned, a building can attain different certification levels, namely Certified, Silver, Gold, or Platinum. The LEED certification system relies on several critical criteria, including Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation in Design, and Regional Priority Credits.

The German Sustainable Building Council (DGNB) is a sustainable building certification system originating in Germany in 2007. DGNB conducts a comprehensive assessment of a project's sustainability, addressing ecological, economic, sociocultural, and functional dimensions. It places a strong emphasis on a life cycle perspective, considering the entire journey of a building from construction through to demolition and recycling. DGNB awards quality labels in various levels, including bronze (not applicable to new buildings), silver, gold, and platinum. For exceptional architectural excellence, buildings with gold or platinum status may also qualify for a diamond award. Notably, entire neighbourhoods can also attain certification. DGNB's evaluation encompasses a wide array of areas, including ecology, economics, and social aspects. While prerequisites must be met, optional criteria offer opportunities for additional points

The Lithuanian Green Building Council has introduced a regional building sustainability assessment standard and certification system tailored to the Lithuanian market. This system provides an objective evaluation of buildings in Lithuania, taking into account local natural conditions, legal requirements, and market demands. It applies to various building types and offers ratings that range from Assessed to Good, Very Good, Excellent, and Outstanding. The LPTVS assessment system encompasses eight categories: Health, Energy, Transport, Land Use and Ecology, Materials, Waste Management and Pollution, Project Management, and Water Management. Within these categories, there are 29 specific criteria used for assessment.

The **Polish Green Building Association (PLGBC)** has launched the GREEN HOUSE certification system, which evaluates the energy and ecological efficiency of residential buildings. This system applies to both multi-family and single-family homes and assesses sustainability across all phases, from design stage, during construction and operation. The criteria encompass six key areas: investment management, location and site, materials and resources, user health and comfort, water management, and energy consumption optimization

Level(s) is a freely available European tool and framework designed for the evaluation of sustainability in the construction sector. It places a strong emphasis on circular economy principles and assesses various aspects including embodied carbon, material and water use, health and comfort, and climate change impact. The name "Level(s)" is derived from the different levels at which a building can be assessed.

This framework comprises three assessment levels: Level 1 encompasses fundamental principles, Level 2 involves checklists, and Level 3 evaluates as-built parameters. Additionally, Level(s) supports e-learning, aligns with European Union (EU) sustainability goals, and promotes the use of Building Integrated Modelling (BIM) for data sharing in the construction sector. The assessment within Level(s) addresses six key topics referred to as "macro-objectives," which encompass greenhouse gas emissions, material cycles, water use, indoor comfort, climate resilience, and cost optimization. Each macro-objective consists of specific subtopics for detailed evaluation.

The **QNG Ready certification** is an official government-backed label of approval that takes a holistic approach to assessing a building and its surrounding environment as an interconnected system. Unlike solely focusing on energy consumption during use, this certification evaluates the entire life cycle of a building. This includes aspects such as production, subsequent material recycling, and health considerations, among others. The QNG Ready label is a mandatory requirement for securing a promotional loan as part of the BEG promotion. The criteria outlined in the QNG manual ensure that a building adheres to standards related to climate protection, conservation of natural resources, health protection, and the quality of the planning process.

6.2 THE MOST IMPORTANT TIPS AT A GLANCE

Walls

- Choose ecolabelled wallpaper. It's eco-friendly and promotes better indoor air quality.
- Avoid vinyl wallpapers, which can outgas plasticizers and other harmful substances.
- Ideally, avoid using wallpaper as they may contain harmful chemicals such as solvents, plasticizers, and formaldehyde.
- Note that even woodchip may not be entirely safe as it can contain small pieces of wood, often from recycled wood, which may have residues of wood preservatives and other chemicals.
- If you plan to use wallpaper to decorate your walls, it is important to ensure that the wallpaper glue you use does not contain fungicide.
- Dispose of wallpaper residue in household waste, not in wastepaper as adhesive and paint may remain.
- When using tinting paints and paint mixing systems, make sure that they do not contain any allergenic preservatives.
- Use silicate and lime paints, as these are not only suitable for allergy patients but also do not contain any preservatives. Their high pH value also makes them more resistant to mould.'
- When choosing wall paints, make sure that they do not contain essential oils or resins. These can trigger allergies and are often problematic for allergy sufferers.
- Use an ecological filler without acrylates to fill holes and cracks in the walls.
- Once renovation work has been completed, it is important to dispose of wallpaper or paint residues properly. Follow the instructions on the packaging. Liquid paint and varnish residues as well as solvents should be taken to the local hazardous waste collection point, which is often offered by the city or some DIY stores.
- It is important to make sure that there is enough ventilation in the area when painting. Additionally, it is recommended to wear appropriate protective clothing to stay safe.
- Note: The simpler and more natural the paint ingredients, the more sustainable they will be. Avoid synthetic and non-biodegradable substances such as petroleum and chemical preservatives and solvents in paints.
- Clay paint is made from clay flour, plant starch and natural cellulose. It is extremely environmentally friendly and good for indoor air quality. It can be mixed with water before use. It is even available in paper bags, eliminating the need for plastic buckets.

Floors

- To avoid possible odours or harmful substances, choose loose laying rather than glueing when installing flooring.
- Avoid PVC flooring as it may contain potentially harmful substances. PVC flooring often contains plasticizers or tin to make it more resistant to light. Both substances can be harmful to your health.
- Ensure that hard oils do not contain solvents or carcinogenic oximes when using them on wood floors. To ensure the quality of the products, look for recommended ecolabels.
- If you have allergies, it is recommended to use tile, granite, or hardwood flooring as they are easy to clean and do not collect dust. This helps create a low-allergen environment.
- If you're looking to use real wood in your home, it's best to go for floors made from organic forestry. Look for floors that have been produced using ecological forestry practices, which are often labelled with ecolabels like FSC.
- When choosing parquet or wooden floorboards, it's important to make sure that they haven't been sealed with solvents and formaldehyde. An eco-friendlier option is to treat the floors with oil or wax instead of sealing them.
- When choosing a carpet, it is recommended to go for models with fleece or textile backing rather than plastic backing. Plastic backings can crumble and release harmful substances that can be dangerous to health.
- When installing carpeting, it is best to use double-sided tape or biological adhesive instead of conventional glue. These alternatives will help to minimize the release of harmful substances.

Lacquers and stains

- Paints and stains often contain harmful plasticizers and solvents, so it's best to paint outdoors.
- When buying paint, choose environmentally friendly and low-emission products without synthetic plasticizers. These can cause headaches and nausea.
- It is recommended to choose natural resin paints. This will help to minimize the use of harmful ingredients and promote a more environmentally friendly renovation.

Adhesives and sealants

- When renovating, choose water-based adhesives and sealants to minimize harmful solvents and plasticizers.

General Tips

- It is important to start planning your home renovation early and give yourself enough time to select the materials for painting walls, ceilings, and floors.
- When renovating your home, only use products specifically designed for indoor use.
- It is important to note that not all products sold in organic DIY stores are automatically safe for your health. Some clay paints, for instance, contain allergenic preservatives. It is advisable to read the product label and verify its composition.
- It is important to review safety data sheets and sheets for construction materials such as foams, sealants, paints, and adhesives.
- When planning, choose products with a simple composition instead of complicated composite materials.
- If no products with a recognized ecolabel are available, it is advisable to choose products that list all ingredients or that have been tested for outgassing substances.

Impressum

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Osterstraße 58, 20259 Hamburg

www.bef-de.org

Authors: Gražvydas Jegelevičius, Agnese Meija-Toropova, Mecki Naschke, Nameda Belmane, Ilze Neimane, Andrzej Tonderski, Aleksandra Rutkowska, Christiane von Knorre, Rose Schläfli, Sara Lohse, Lucas Schmitz, Siobhan Protic, Fee Widderich

Layout: Nadine Rybacyk

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Baltic Environmental Forum Deutschland
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