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# From the Cradle to the Grave:

Life-cycle assessment, or cradle-to-grave, looks at how a building material is made from the very start of the process to the end of its life. It is a way to determine how environmentally-friendly a material really is. Although it is mainly concerned with the 'embodied energy' of a product (i.e. how much energy has been put into this material to create it, use it and get rid of it at the end), we can also use each stage to take stock of other environmental concerns. Does it create poisons? Does it destroy habitats? Does it increase waste?

## Is it Really Green?

For example, a rigid-polystyrene insulation product may have excellent thermal properties. It would be fair to think, therefore, that this is a great environmentally-friendly product. If you use plenty of this insulation in your walls, your heating bills will be low; you will have a lower carbon footprint. You are doing your bit for the environment.

However, in its manufacture, this particular insulation product may use pretty nasty raw materials, such as naphtha (petrol-like volatile liquid – some forms may be carcinogenic), pentane (highly flammable gas which continues to off-gas even after the insulation has been transported to the building site. Run-off into water kills fish and molluscs, affects the physiology of certain types of plankton and poisons and/or kills other plankton species), styrene monomers (classed as a hazardous chemical – chronic exposure can result in tiredness, lethargy, memory deficits, headaches and vertigo; since June 2011 the jury is out on whether or not it is carcinogenic) . It is not looking quite so environmentally friendly any more.

It scores quite well during it ***Use Phase***, when it is in your walls, insulating your home and keeping your heating requirements down.

What happens in years to come, when nobody lives in your house anymore? Will your house be demolished to make way for a new development? Will it simply be left to fall into ruin over the decades and centuries to come? What happens to your indestructible foam insulation then? Can it be broken down? Can it be recycled? Will it require a high-carbon manufacturing process or the use of toxic chemicals to make it re-usable? Or will it just go to landfill? This is far from environmentally-friendly.

It is important when deciding on which green building materials you want to use, that you do not just concentrate on the ***Use Phase*** but look at the full life-cycle of the products.

## Cradle Phase – Accessing the Raw Materials

### Mining and Quarrying

Many building products have a very real physical impact on the environment at the very beginning of their production, as raw materials often need to be mined or quarried. Gypsum rock for plasterboard or limestone for Portland cement are examples.

### Finite Resources

Apart from the destruction of habitats caused by mining and quarrying, once the rock has been extracted it cannot be replaced. Oil is another finite resource under severe pressure and is the basis for most foam and plastic products (although research into and production of bio-plastics is a growing field).

## Unsustainable Management of Renewables

Even when looking at the front runners in the environmentally-friendly stakes, the source of the material must be carefully examined. Timber is recognised as being a desirable ecologically-sound material. Coming from a sustainably managed forest, timber is a renewable resource, which requires relatively little processing and contributes comparatively little $CO_2$ to the atmosphere.

However, this is not the case if the timber is coming from barely legal logging companies stripping the resources of developing countries. The same is true of certain bio-crops, grown for green fuels and plastics. If they are replacing food crops for the indigenous people and destroying animals' habitats, then their environmental credentials must be called into question.

## Innovations in Sourcing Raw Materials

Building materials manufacturers are becoming more and more aware of the need to be environmentally responsible at every stage of production. This is leading to worthy innovations such as using GGBS (ground granulated blast-furnace slag) in the manufacture of concrete. GGBS is a by-product of iron which has been heated in a blast-furnace, so no quarrying is required. It can replace the ordinary Portland cement in a concrete mix by an average of 50%, up to 85% in certain circumstances.

Gypsum board manufacturers are looking at recycling the off-cuts of old gypsum boards to use as raw material for new boards. Already the use of recycled newsprint in the manufacture of gypsum boards is becoming standard practice.

## Toxic Chemicals

Synthetic products use multiple chemicals as base ingredients. In their raw state, they can pose a threat to human and animal health. Their disposal can result in damage to habitats and eco-systems.

### Transport

In some cases, manufacturing plants may be located where the raw materials are sourced. More often than not, however, raw materials need to be transported to the factory. Transport by ship is more environmentally friendly than by plane. Transport by train is more environmentally friendly than by road.

## Manufacture Phase – Processing the Raw Materials

After the raw materials have been extracted or collected, they are delivered to a factory or plant, where they are turned into recognisable building materials by one process or another.

### Production of $CO_2$

Many require extremely high levels of heat to transform them into the finished goods. Bricks are fired in a kiln at approximately 900-1,000°C. Portland cement is fired at 1,500°C. This process releases huge amounts of $CO_2$ into the atmosphere.

To make things complicated, this is not always a marker for an environmentally-damaging process. In the production of lime, limestone is also burned at 900-1,000°C. However, when lime is in its ***Use Phase***, it reabsorbs carbon from the air as it turns back into limestone through a process called carbonation. It absorbs between 75% and 100% of the $CO_2$ released during its production, essentially neutralising the major negative environmental effect of its manufacture.

### Toxic Waste

Many building materials use toxic chemicals in their manufacture, such as the example of the rigid foam insulation above. Some processes require chemical reactions which release toxic gases into the atmosphere or produce contaminated effluent. Synthetic paints are an example of this. It is difficult and sometimes impossible to render these by-products completely harmless and generates the problem of where to dump or how to contain this toxic waste.

### Multiple Processing

Some building materials may need multiple stages of processing to create the end product. Some or all of these stages may incorporate high fuel and electricity use, release of harmful gases and effluent, and produce landfill waste. They may need to be transported long distances between one plant and the next for each stage of production. A building material like this has high embodied energy.

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### Minimal Processing

In general, products which require little processing score better from an environmental standpoint when compared with products which require heavy processing. This can be observed when examining products which remain relatively close to their original natural state – sheep's wool insulation or earth plasters would be examples of this.

### Waste as a Resource

Alternatively, products which use the waste by-product of another industry can also gain green credentials. The processing has already been carried out by the other industry and it eliminates the problem of waste for that original industry. GGBS (ground granulated blast-furnace slag) used to make eco-cement and concrete is a good example of this.

## Use Phase – The Product in Place

Environmentally speaking, when looking at how a building material performs during its 'working' life, you want to see a material that does not contribute further to the destruction of the planet's life support systems.

A material or product which reduces energy use in the building is desirable, such as insulation, a highly efficient heating system or solar water collectors. So is a product which reduces resource use, such as low-flush toilets or low-flow taps. Products which endure and therefore do not require regular replacement are worth bearing in mind. Our consumer society tells us to throw something away and replace it with an entirely new version, using yet more of the planet's resources.

Building materials which reverse some of the damage done during their ***Cradle*** and ***Manufacture Phases*** also display ‘green’ characteristics, such as lime discussed above, which reabsorbs its weight in $CO_2$. Building materials which are inert, which do not off-gas poison into the atmosphere, should also be considered.

## Insulation

Materials with good insulation properties score well in the ***Use Phase***, as they minimise the need for heating.   Over years and decades, this can have a significant bearing on the overall carbon footprint of a building throughout its lifetime. Sometimes, this positive impact is enough to eliminate some or all of the negatives accumulated during the material’s manufacture. However, a natural insulation, such as hemp, wood fibre or sheep’s wool, while it cannot always achieve as high insulation properties as a foam insulation, will have accumulated very little in the way of negatives during production.

## Healthy Environment

With products such as insulation, the health of the occupants should also be a priority. The immediate environment needs to be friendly, as well as tackling the challenge on a global scale. Natural, breathing insulations are preferable to closed-cell foam insulations, as the latter can promote the growth of toxic moulds in certain situations.

## Endure, Maintain and Repair

Materials with long life spans and which require minimal maintenance are desirable. Do not confuse minimal maintenance (low-tech and not too much effort) with the zero-maintenance that is often advertised with many modern building materials and components. An example of this might be a uPVC window, which is ‘maintenance-free’ and guaranteed to last for decades. I will not discuss the high embodied energy and highly toxic gases produced during the ***Manufacture Phase*** of these windows here. Currently, uPVC windows last about 20 years, possibly 25 if you are lucky. Once they have deteriorated, they cannot be repaired. They must be replaced. Conservation carpenters and joiners repair timber windows which are over 100 years old. Only the damaged section of the window need be repaired.

## Salvaged Materials

Incorporating salvaged materials during the ***Use Phase*** can seriously increase a building's environmentally-friendly credentials. The ***Cradle*** and ***Manufacture Phases*** are eliminated from the equation. Salvaged slates reduce the need for quarrying. Salvaged timber has already been dried and milled.

Quite often, building materials from the pre-consumer days are of exceptionally high quality, far superior to their contemporary equivalents. Nowadays, products are built with a shelf life. The manufacturer has designed them to fail in 10 or 20 years time. It is uneconomical, often impossible, to repair them. So you, the consumer, are forced to buy a new product and the manufacturer gets to keep on manufacturing. This is not sustainable.

## Waste

The issue of waste needs to be addressed at this stage. Many building components are modular, such as plasterboard and plywood or even bricks and blocks. Architects and designers should make an effort to accommodate these building modules, but it is obviously incredibly restrictive on the design and virtually impossible to achieve throughout an entire building.

In Canada, there is a pioneering scheme where a gypsum board manufacturer collects off-cuts from site to use as raw material for the next batch of gypsum boards. Cut bricks and blocks could be used as hardcore for road building, etc. However, this level of waste management, recognising waste as a resource, is a rarity.

Another consideration regarding waste is the use of products which set quickly. If a builder mixes a batch of concrete and has too much left at the end, it is waste. If the same builder was using lime, once stored correctly, the lime would keep indefinitely. In fact, in the case of lime putty, it would improve in quality over time. The same is true of earth plasters.

### Transport

Materials which can be delivered to site locally are preferable over materials which must travel long distances. However, if there is choice between using a local material known to harm the environment or a truly green product which must be imported from overseas, then the foreign product can make sense.

## Grave Phase – Disposing of the Product

### Natural Decomposition

The big advantage with many natural products is that if they are left exposed to the elements, eventually they will simply disappear back into the earth. Timber will rot. Earthen buildings will dissolve. Natural insulations, such as hemp, sheep's wool, straw or wood-fibre, will decompose. There is nothing in their make-up which will damage the environment as they break down.

### Ease of Re-Use

Obviously a stone building will not disintegrate to dust. However, if lime mortar was used, the walls can be dismantled easily. The stones can be removed and reused, as good as new. If a product can be re-used with little or no additional processing, it is a positive from an environmental point of view.

### Are All Components Safe?

Old timber, if it cannot be reused as a building material, can be used as fuel. You need to be careful that it was not treated with toxic chemicals in the past. The same goes for OSB (oriented strand boards) and plywood. These are often viewed as environmentally-friendly, particularly as they use up much of the waste wood from the saw mills. This is, indeed, often the case. Sometimes, however, while the basic material, the wood, may be safe; the glue or binder may contain harmful ingredients.

### Steel

Steel, even galvanized steel (not scoring so well during the ***Manufacture Phase***), will eventually rust away. At the time of writing this article, I am unclear as to whether this could result in increased levels of iron in the soil and whether or not this would necessarily have a negative impact.

### Concrete and Cement

Concrete must be broken up with brute force. It is useless except as a form of hardcore and is rarely used in this way. Concrete blocks and bricks which have been bonded with cement mortars and coated with cement renders have little or no possibility of being re-used. The cement is stronger than the block or brick, making it virtually impossible to separate them without damaging the blocks or bricks themselves.

### Plastics

While some plastics deteriorate under UV, many plastic-based products will not disintegrate and present little opportunity to be reused or recycled. An Irish company turns its redundant foam insulation into packaging loose-fill cushion-chips. Carpets manufactured from recycled plastic have been around for a while.

### Cradle to Cradle

Manufacturers are recognising the environmental (and financial) value of giving new life to their product when it reaches the end of its first tour of duty. This is known as ***Cradle –to-Cradle***. However, with many building materials and products, it can be difficult to assess at the ***Use Phase*** whether or not the manufacturer has a plan in place for the ***Grave Phase***.

In conclusion, there are many phases in the life of a building product. To correctly decide whether or not a material is truly environmentally-friendly, each step along the way must be considered.