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Section 1 Sustainability Issues

INTRODUCTION

It is important for designers to understand the broad cultural framework within which they work and in no area of the design field is this more important than sustainable design. Design decisions, like the decisions of consumers and politicians, are driven by values and values are formed in response to broad issues. This first section of the Sustainability Pack seeks to draw your attention to some of the areas that you need to think about.

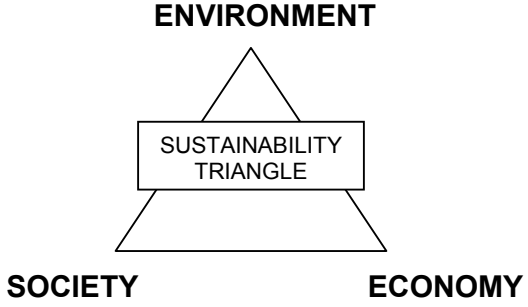
1.1 WHAT IS SUSTAINABILITY?

According to the World Commission on Environment and Development, 1987, sustainability is understood to be **"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."**

Three examples of what this means:

Reducing reliance on fossil fuels in order to maintain their levels for future generations	Preventing further destruction of rainforests and other important habitats and resources	Changing our habits to reduce the impact of our lifestyle on the environment

Sustainability is about responsibility, and has three main areas of focus; the environment, society and the economy. These can be represented in the Sustainability Triangle:



As consumers, we have a lot of control over what is manufactured, and how it is manufactured. Each time we buy a product, we are effectively "electing" or "voting" for the company who has provided it. If we buy products from companies who are ethically irresponsible, e.g. companies that exploit their workers, or companies who are not concerned with the environment then we are "electing" un-sustainable companies. If we use our votes to support companies who produce sustainable products, such as free-range eggs or recycled paper, we will elect a group of companies who will re-invest in the planet, and share their success with us all.

Environmental responsibility

Environmental responsibility means ensuring that our actions and lifestyles do not have such a negative impact on the environment that the planet's resources are being used at un-sustainable rates – e.g. moderating our energy usage and method of generation to take advantage of renewable energies, and to maintain fossil fuel levels.

Social responsibility

Social responsibility means ensuring that other people's quality of life and human rights are not compromised to fulfil our expectations and demands – e.g. buying products and food which has been fairly traded, and manufactured in good conditions.

Economic responsibility

Economic responsibility means ensuring that there is an economic benefit both to the region from which the purchase came and to the region in which it is marketed.

As designers, however, we have even more responsibility than consumers, and we have the potential to determine what and how people consume goods. This is eloquently expressed by Victor Papanek in his book *Design for the Real World:*

> "There are few professions more harmful than industrial design, but only a very few… by creating whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes that pollute the air we breath, designers have become a dangerous breed… In this age of mass production when everything must be planned and designed, design has become the most powerful tool with which man shapes his tools and environments (and, by extension, society and himself). This demands high social and moral responsibility from the designer."[1]

The nature of a design problem is that it has many solutions. Generally, there is no "right" solution to these problems, but a range of solutions, which have different benefits, failures and consequences. As a designer, one must chose a solution that is better than the others – but this depends greatly on the designer's personal or imposed priorities.

Sustainable Design problems also have many solutions – but in addition to the usual areas of concern, sustainable design must also consider the social and environmental implications of the product during its entire lifespan – production, use and disposal. For example, a solution which improves the life span of a product may put people out of work by reducing the demand for replacement products. A solution which reduces cost of manufacture and of retail price may have negative implications on the working conditions in the place of manufacture.

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[1] Papanek, Victor (1972) *Design for the Real World*, Thames&Hudson, London 1985

Designers have some control over consumers and have direct control over how products are manufactured, assembled, distributed, used and disposed of. It is the responsibility of the designer to specify the product's characteristics, and the time has come to start specifying sustainable qualities as central aspects of successful design.

1.2 THE EFFECT OF GLOBALISATION

As different communities are exposed to the same influences, through film, television, the internet and other global media, both personal and cultural expectations within these communities are changing to become similar to each other. Dominant companies and cultures are impressed on less dominant cultures – for example the introduction of McDonald's restaurants throughout the world, the release of Disney films with slim, big eyed heroines, and the popularity of blockbuster movies from the USA. Supermodels and fashion magazines fuel the demand for beauty and *dictate a certain image, which becomes an impossible ambition for people all over the world to become.* Rawiwan, a young Thai woman, complains of being too dark and wishes her skin were paler, whilst Emily, a young British girl, yearns for her skin to be more tanned. Increasing amounts of money is being spent on cosmetics and clothes, with the only real winners being the companies who make a profit from human insecurities.

Globalisation is when communities start converging towards the same trends. Using the same language, using the same slang, wearing the same clothes, eating the same food or reaching for the same goals. As global communication increases and becomes more accessible, it is not only news that travels fast; fashions, jokes and even knowledge. The tendency is for the dominant culture to be adopted by others, for example baseball caps are worn all across the world, in many cases as a fashion statement rather than an indication of loyalty to a particular team. However, knowledge and information from other communities is also made available, which becomes incorporated into other cultures. There may be a loss of national identity, but there is a delicate mixture, or homogenisation, of cultures to create a carefully balanced multi-cultural society which we are now able to enjoy.

Globalisation sees regional values become global values – with people all over the world wearing New York Yankees baseball caps[2]

[2] Image courtesy of www.newyork.yankees.mlb.com - last visited 23-06-2002

Example:
Recent interior decoration trends in the UK have been heavily influenced by Japanese and Scandinavian cultures and traditions.

Interior design in Britain and other countries has been influenced by the Far East[3]

Example:
Embroidery and designs from sub continental Asia have been incorporated into fabrics, furniture and fashion in the west.

Silk sarees. These patterns and bright colours have influenced design in Western countries[4]

As a response to globalisation, there are some areas within a culture which become more distanced from the generic "norm" – those who purposefully react in the opposite way, by rejecting the influence of globalisation.

Example:
Hollywood makes "blockbuster movies" – which are expected to draw millions of viewers, and must cater to these mass audiences. As a response to globalisation, independent filmmakers move away from the "guaranteed success" formula used by Hollywood to make thoughtful and expressive films, which engage the viewer on many levels. Independent films have become more successful and confident as audiences grow tired of Hollywood.

[3] Image courtesy of www.haikudesigns.com/images/ collge2001.jpg – last visited 23-06-2002
[4] Picture courtesy of: http://www.indiamart.com/deepikaoverseas/gifs/silk-sarees-pic1.jpg - last visited 23-06-2002

In some communities, the loss of a national identity has lead to the creation of a local identity, for example, in Spain people seem to have more association with their region than with their nation, and in the UK there is tribalism between countries, regions and cities – for example Scotland & England, Liverpool & Manchester, and Lancashire & Yorkshire.

The world is becoming “smaller” as communication between countries increases. The internet allows instant communication across the globe, it allows information to be shared with millions of people. Advances in telecommunications makes international telephone calls cheaper and more accessible, providing communication between friends and family members that may otherwise be too costly to consider. It has been described as a “global village” – a cosmopolitan blend of ideas and traditions, which has the potential of enriching each of our lives. However, the idealistic is not necessarily the realistic, and globalisation has both positive and negative implications.

1.3 CONSUMERISM AND ITS EFFECTS

The majority of the developed world live in a consumerist society. Mechanically functional products are discarded because they are no longer fashionably functional, for example; kitchen appliances, clothes, carpets, cars etc. What Europeans spend annually on ice-cream alone would provide water and sanitation for the world's population[5]. To purchase is to make a decision, and to make a decision is to exercise control. There is a prevailing attitude that to own is to be comfortable.

> **Example:**
> To own a coffee-bean grinder allows fresh coffee to be ground and enjoyed when and where the user wishes, rather than having the coffee ground at the place of purchase, and the ground coffee then going stale or losing its freshness.

However, 100% of coffee drinkers owning a grinder of their own has far more environmental implications than one coffee shop owning a grinder which is used by everybody.

Three different ways of reducing the environmental impact of grinding coffee:		
Re-design grinders to be more sustainable, e.g. use renewable energy sources, materials with low environmental impacts and less raw material	**Develop a container which keeps ground coffee fresh for a longer period so users can still enjoy fresh coffee, e.g. using recyclable foil**	**Arrange distribution of freshly ground coffee – in the same way that milk is delivered in the UK**

One of the most dominant factors in both traditional and sustainable design today is cost. To reduce cost is to increase profits.

> **Example:**
> "Why should I pay €500 for a table which is locally made when I can get one from a superstore for €75?"
>
> The €500 table is hand crafted by a skilled tradesperson, using sustainable materials and will last for 40 years.
>
> The €75 table is mass-produced in a factory with poor working conditions in a third world country, which takes advantage of poverty in the region. It uses less material, but this is not sustainable, and it will last for 4 years.
>
> **Example:**
> "Why should I pay €80 for an environmentally friendly bookshelf when I can get a normal one from a superstore for €20?"

[5] Source: www.oneworld.net - last visited 21-06-202

Cardboard bookshelf which is its own packaging

How could a designer or salesperson use their expertise to encourage the consumer to buy this more sustainable product?

Fifty years ago, furnishing a house was very expensive, and products would be considered very carefully before anything was bought. The consumer was more likely to demand higher quality items, which would not need replacing for years, and would be prepared to inspect the products close up. This often meant that the products were made locally, or distributed to local retailers. Now consumers spend less time considering the quality and lifespan of the products, and many purchases are made from catalogues or over the Internet, where the buyer does not even see the product until it is delivered to their house. The global nature of the internet means that consumers can buy things which are not manufactured locally, and require long-distance transportation. Factors which influence today's purchases are more changeable – for example current fashions, and whether the item "fits in" with the consumer's other belongings. Products become less "precious" as they are more easily replaceable. As mass production and competition brings down prices, consumers have more flexibility, and tend to change their home environment more often, either through re-decorating or replacing old furniture.

This "throw-away society" does have positive social implications. As people buy new things to replace old ones, more second hand items are made available, giving other people the opportunity to change their environment. Second hand goods are often sold through charity shops, providing a service to the community's poorer citizens, and also raising money for different charities. In this way, furnishing a house can be more affordable through the re-use of mechanically functional products.

Current trends show that consumers are beginning to return to the more old fashioned behaviour of rejecting cheaper, poorer quality items in favour of higher quality products. This is partly due to a current fashion of "individuality" where mass produced products are rejected for hand made ones. This may have a positive environmental effect, but it is not a solution.

1.4 MANUFACTURE ABROAD

i) Cheaper labour

Companies often chose to move their manufacturing departments abroad, partly because of the cheaper labour available, but other reasons include being closer to suppliers and being closer to new markets. This provides employment to the citizens of the host country, but jobs are lost in the country that the company's has moved from.

Britain alone has lost a large part of its manufacturing industry, with the majority being lost to countries that offer cheaper labour. One textile factory is closed every day in Britain[6], and imports have risen by 40% in the last five years. The textile industry used to be Britain's largest employer, but now is the fourth largest manufacturing employer, employing more than 340,000. The motor industry has also been badly affected, with highly publicised closures across the country.

CASE STUDY

James Dyson, the inventor of the famous dual cyclone bagless vacuum cleaners, has also decided to move his manufacturing base to the Far East. He has been a long-standing supporter of British manufacture and this decision has shocked employees and trade unionists.

He cites the driving forces behind the move as lower labour and production costs, and proximity to suppliers.

Workers in Malaysia, the proposed site for the new plant, will be paid approximately £1.50 per hour, in contrast to the £4.10 per hour paid to the British workers.[7]

Dyson intends to put the money saved by moving manufacture out of Britain, approximated at 30%, back into the Research and Development department, which he describes as the "heart and soul" of the business, and intends to keep in Britain.[8]

ii) Environmental legislation

As environmental laws demand increasingly high levels of performance, companies are moving manufacture to countries without such strict laws, or to countries who have not got the resources to enforce their environmental policies.

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[6] According to the Knitwear, Footwear and Apparel Trades Union

[7] source: www.bbc.co.uk - last visited 23-06-2002

[8] Please note that no reference is drawn between Dyson's manufacture abroad and indications elsewhere in this report of poor working conditions abroad.

CASE STUDY

In the border regions between the USA and Mexico, there persists the illegal disposal of hazardous waste, posing significant threat to human health and the environment, and contaminating ground water supplies.

Surface and underground water is in short supply, and is poor quality. Urban areas face increasing levels of pollution.

Maquiladoras – foreign owned manufacturing plants along the border regions of Mexico – are alleged to contribute to the illegal dumping of toxic substances and have no on-site water treatment facilities. This type of pollution is illegal in both countries. Communities have been created around the *maquiladoras* due to the availability of employment, but these communities add to the pollution due to poor sanitation.

Mass-migration from southern Mexico to the border regions is caused by the availability of jobs in the *maquiladoras*, but adds to the pollution, overcrowding and to tensions along the border. Foreign owners of *maquiladoras* are being encouraged to invest in the infrastructure of southern Mexico, to encourage people to stay in the south.

There are many environmental projects involved in improving the area, but there is little contribution to these projects from the private companies who are willing to take advantage of the financial benefits of manufacture in the region. Clean up costs for the entire border region are estimated to be twenty billion dollars.

Activity

"Moving manufacture to a site where the company can get away with polluting is cheaper than changing manufacturing practices to meet environmental legislation."

Discuss the above statement, considering the real "cost" of polluting. What incentives might discourage companies from polluting?

iii) Working conditions

Moving manufacture to third world countries provides jobs and incomes to people who are grateful for the opportunity. However, employers know that there is a great need for employment in these countries, enabling some employers to take advantage of their employees. Human rights are compromised by the working conditions in many factories and manufacturing plants, and employees often have to work in appalling conditions, but because they rely on their income from the job, they are unlikely to complain or refuse to work in the conditions. The infrastructure is also weaker, without access to unions or fair representation.

As investors, these companies have enormous potential to save money, but also to help improve the situation in their host country. If a little of their savings was put back into the workers' lives, e.g. through health care, education or pensions, the company would be investing in the future of their workers and

this would help to break the cycle of dependence, and improve relations between the company, the community and the consumer.

Unfortunately, the companies that operate in these conditions are unlikely to respond to workers' complaints or demands, but they will react quickly if their sales are threatened. Consumer groups have influenced companies such as Nike to improve the conditions in their factories. Consumers have a great influence over a company's behaviour, by wielding a strong weapon against exploitation – the weapon is *buying power.*

iv) Child labour

In families with low incomes, generally in developing countries, sending a child to school is not only expensive in terms of fees and books, but also in terms of loss of potential income. If that child can work instead of attending school, he or she can bring an extra income to the family. Additionally, if the child has no family to provide support, he or she is forced to work, in order to survive.

Some employers, both foreign and native, see this need for employment as an opportunity to reduce manufacturing costs, and they employ the child on a low salary, often in poor working conditions. Young children are forced into the working environment, potentially hindering their natural growth – physical, educational and emotional.

A young child works in a physically demanding job which could impair his physical growth[9]

According to Geeta Dharmarajan in her interview with One World Online in 1997, child labour is highest in areas of high adult unemployment. She states that

> "Parents could get employment if their children were not working - but children are cheaper."

Paulo Evaristo Lins, the Cardinal of Sao Paulo, Brazil believes that

[9] Image courtesy of www.oneworld.net/guides/ chld_labour/front.shtml – last visited 23-06-2002

> Unemployment destroys societies, but child labour shames all society".

Consumer groups are putting pressure on the government to require labels stating whether child labour has or has not been used in the manufacture of each product.

However, in communities where child labour has been banned, and factories have stopped employing children, there has been an outcry *by the children themselves.*

> **Imagine that you have no money to buy food, and you have to work for survival. A law is passed by people whose children eat three times a day, that prevents you from earning the money you need to eat at all. How do you feel?**

The reason that the children work in bad conditions is that they need to work, and preventing child labour results in preventing needy children to take action against their poverty. Geeta Dharmarajan acknowledges poverty as the driving force behind children going to work, but believes that

> Child labour is self-defeating: if a child cannot study, then the cycle of poverty is repeated - and she will never get out of the slum.

So how are the wrongs of child labour confronted, without denying the children's own needs and human rights? Some suggestions are shown below.

- Providing education in the work place would enable child workers to educate themselves, which would help them to grow and give them more opportunities.
- Providing nourishing meals to employees, not just the standard plain rice which is served in many factories, would ensure that the child eats well and stays healthy, and allow them to use their earnings to better themselves or their family.
- Offering part time work to children who are able to attend school part time would allow children to work and learn.
- Organising working children's clubs in the child's free time would create a social atmosphere where the children can meet and get to know each other, and help them to develop their emotional and social skills.
- Introduce "work experience" for the children's parents, so that adults can be trained by the children. This would create employment amongst the adult population, and may gradually reduce the society's reliance on child labour.
- Encouraging "unions" amongst the working children and advising them of how to negotiate work improvements would give the group a stronger voice to confront employers, and empower the children.

For more information, it is highly recommended to visit http://www2.gol.com/users/bobkeim/child_labour/ which has excellent articles and case studies, including those on the following children:[10]

[10] Images are courtesy of http://www2.gol.com/users/bobkeim/child_labour/ and *New Internatioalist*, July 1997 edition

Assane, 10, works as a shoe-shine boy in Senegal

"I hope I can make a lot of money. I hope I can go back to my village and give all my relatives presents."

Kumar started work age 8 in Nepal. He is now 16.

"It was like a prison, we were locked inside. We worked from 5 a.m. until midnight making carpets and we slept among the machines."

Pablo, 14, works as a street seller in Colombia.

"Although I like my job and I have a lot of friends on the market, I don't choose to work. I work because I must, to help my mother and to pay for my food and so on."

Sawai started work making clothes in Thailand age 13.

" I was very unhappy about leaving home and I was afraid of going to the city, but I knew it was my only hope to continue my schooling."

1.5 FAIR TRADE

What is Fair Trade? A statement on the Network of European World Shops website describes Fair Trade as follows:

> **"Fair Trade puts people before profit.**
> It is a partnership between producers, traders and consumers who are working to remove the disadvantages suffered by producers, to increase producers' access to markets and promote the sustainable development process.
> Fair Trade works to create means and opportunities for producers, especially disadvantaged, small-scale producers, to improve their living and working conditions. Its mission is to promote social equity, environmental protection and economic security through trade, awareness-raising and campaigning.
> **Fair prices** are ensured to producers. That price covers a reasonable income, environmental protection and economic security
> **Long term co-operation** allows producers to finance the development of their communities.
> **Good working conditions** are experienced by producers in Fair Trade. They have a voice about their work and organisation.
> **Respect and promotion of human rights**, especially those of women, children and disabled people, are the basis of Fair Trade.
> **Assistance to the development** of ecologically sound products and care for sustainable production are established in the Fair Trade partnership." [11]

To understand Fair Trade, it is important to look at unfair trade, in order to gain perspective:

CASE STUDY

> It is common practice in the Western Bengali area of India for moneylenders to offer money in return for labour. Fathers often borrow from these moneylenders to pay dowries for their daughters' marriage. In a typical example, a father commits to working in a carpet factory for a number of years in order to pay off the debt. However, the working conditions are appalling, and the father's labour is unpaid, so he develops further debt when borrowing more money to feed his family. This traps him into working at the carpet factory for longer, and his debt increases in a cycle, which cannot be broken.
>
> The carpets are then described to exporters as authentic, traditional hand-made Indian rugs, and are sold at huge mark ups, increasing the moneylender's wealth and his ability to trap more labourers. The workers receive none of the profit and only the middleman benefits.
>
> In contrast, at the Tibetan Children's Village in Dharamsala, Northern India, refugees from Tibet make and sell carpets as a community, to support and educate themselves. The hand-knotted carpets are made to patterns which have been handed down through the oral tradition. As a community, there is a good working environment, and continuity of employment and income, which helps to prevent the cycle of debt, and keeps the producers in control of how their profits are spent.[12]

[11] Quoted from http://www.worldshops.org/fairtrade/index.htm - last visited 23-06-2002
[12] Source: Shukriya – Trading Policy. Shukriya is a fair trade company working in India and Nepal

1.6 SUCCESS STORIES

Wind-up radio

BayGen wind-up radio is manufactured in Africa for an African market[13]

The BayGen wind up radio is fully recyclable, and relies on renewable energy sources – hand power. The radios were originally manufactured locally by disabled people in South Africa. The inspiration for inventor Trevor Bayliss was the need to circulate information in Africa to help prevent to spread of AIDS[14]. In a continent where many people are illiterate, have limited access to electricity and cannot afford batteries to power radios, the wind-up radio is an ideal solution to social, economic and environmental issues.

The technology, in conjunction with organisations such as the Freeplay Foundation[15], opens up information, assistance and education to people throughout the world regardless of literacy or location. The Freeplay Foundation structure broadcasting systems in rural areas that educate locals on issues such as; primary and preventative health care, electoral education, getting information to refugees on the move[16], education, conflict resolution and agriculture.

Child relief and you (CRY)

Based on the principles that all children have rights, but when so many are born underprivileged, someone must stand up to take responsibility. CRY is not an international aid charity; it was created by, and has been maintained by

[13] image courtesy of www.webcom.com/infinet/ baygen.html
[14] http://www.ogormans.co.uk/Bayliss.htm
[15] www.freeplayfoundation.org
[16] During the crisis in Kosovo in 1999, 40,000 Freeplay radios were distributed amongst fleeing refugees in an effort for them to keep in contact with the outside world and be advised of dangers. It also helped people to trace lost relatives.

the people of India, who have chosen to do something about the situation on the streets.

"*Every child comes with the message that God is not yet discouraged of man*"
- Rabindranath Tagore

CRY organises schooling and training for underprivileged children, but their facilities desperately need funding. To fund the projects, cards are sold throughout India and exported by Fair Trade companies, featuring both traditional designs, and drawings made by the children themselves. The profits are put into developing the schools and investing in teachers for the children, who are considered "India's most precious resource".

CHILD RELIEF AND YOU

For more information visit: www.childreliefandyou.org

Self-employed women's association (SEWA)

The Self-Employed Women's Association is a group created by a need. It was founded in Ahmedabad, a city on the west coast of India with a high Muslim population. There are many women who, for a number of reasons, are the sole earners for their families, and must work to provide an income to feed their children. SEWA became a meeting of women, discussing their situation and supporting each other. Simple solutions, like operating a crèche system, where one woman looks after the other's children while the other women work allowed opportunities for the women that were not possible before. SEWA now trains women in business and money management, and provide services such as health care, childcare, banking and legal services and organise many campaigns to improve women's rights in the workplace. By coming together, these women have empowered each other, by utilising one another's skills and by giving each other freedom and choices. Women who have been helped by SEWA still support the ongoing work to help other women in the area.

For more information visit: www.sewa.org

Earn and learn schemes

Poor families in India cannot afford the fees of schools, and to send a child to school would be to sacrifice their potential earnings, either begging or working. Some schools offer a nutritious midday meal for children who attend,

encouraging parents to send their children to school where they can learn and educate themselves, and improve their standard of living.

"Earn and Learn" schemes have been introduced throughout India in children's workplaces. The children must work to earn enough money to survive, but at the expense of their education. Without an education, the child will have no resources to step out of poverty, and his or her children will probably also be born into poverty. Earn and Learn schemes aim to teach the child *in* the workplace – simple lessons that focus on encouraging the child to have ambitions greater than the cycle of poverty.

Section 2 Companies and Products

INTRODUCTION

Individual people and groups have recognised for many years that the issues surrounding sustainable lifestyles need addressing. Of course, for companies to get involved, they must be sure of their economic survival. This means adopting approaches that enable them to address the social and environmental issues relating to their work whilst staying in business. Thus consumer behaviour as expressed through purchases and the rules that governments put in place to regulate markets are fundamental to getting companies involved in sustainability.

Companies will respond to the changing market place, so the next section of the Sustainability Pack outlines the factors that are influencing companies. Once a company has made a decision to look at the products it makes and the services that it delivers, people need to decide what can be done. For many years, the advice has been 'reduce-reuse-recycle' and in that order of priority. Reduction in the resources used to make a product (e.g. the materials used) or deliver a service (e.g. the energy used) gives an immediate reduction in the associated environmental impact. Every time a product is reused, either in its original or a modified form, the environmental impact is further reduced. If it is possible to recycle the resources at the end of the product life or once the service has been performed, then there is further potential for reduction. A discussion of the range of meanings that 'reduce-reuse-recycle' can have follows the discussion of factors influencing companies.

One way of getting started is for people in the company to analyse the products and services that they currently deliver and see what issues and ideas emerge. A form of 'reverse engineering' perhaps. Some notes that might help you to conduct such a disassembly exercise on a product conclude this section.

2.1 FACTORS INFLUENCING COMPANIES

Saving money

Companies have realised that making reductions in products' extraction, manufacture and distribution could make direct cost savings. When take back laws such as WEEE and End of Vehicle Life (please see legislation section) are used companies will also save money by designing their products so they are easy to disassemble, repair, reuse and recycle.
Example:
Redesigning a product so it uses less plastic will directly reduce the amount of plastic the company has to buy. Using energy efficient and less wasteful processes can directly reduce manufacturing costs for a company.

New 'green consumer' markets

Eco-design can lead to better quality, innovative new products. From the late 1980s a market sector of 'green' consumers has emerged wanting 'environmentally friendly' products. Some companies saw potential commercial advantage that could be gained by developing 'greener' products.
Example:
Many consumers will check the environmental profile of the company and look for awards and eco-labels like the 'blue angel' before buying.

Competition

If companies do not try to keep up with and predict future legislation they can fall behind with their environmental knowledge and design work. If their competitors' designs are environmentally superior companies unable to replicate this level of environmental performance could face financial ruin.
Example:
With the support of Greenpeace and in defiance of competitors' contentions, the East German company DKK Scharfenstein/Foron developed the world's first refrigerator that was free of FCs and CFCs, called 'Greenfreeze'. There is evidence that FCs and CFCs weaken the ozone layer, which protects us against the sun's radiation. The refrigerator was launched onto the market with the support of purchasing guarantees. A few months following the product launch the other manufacturers had to follow suit and offer their own refrigerators free of FCs and CFCs.

Keeping a good environmental image

Environmental organisations can use the media and influence consumers for or against companies.
Example:
The appeal made by environmental organisations, notably Greenpeace, to boycott Shell because of its plans to sink the 'Brent Spar' oil platform was publicised very rapidly via the media. As a consequence Shell found itself obliged to revise its plans and dispose of the platform on land.

Protecting the health of workers

Trade unions defend the interests of workers. Many agreements have included clauses relating to the environment.
Example:
In the late 1980s the German trade union IG Metall organised a campaign titled 'crimes on company premises' which aimed at the substitution of hazardous substances in solvents (e.g. CCs) used in the companies.

Corporate social responsibility

Increasing numbers of senior managers have begun to regard the environment as an area of corporate social responsibility. Managers can also have pressure from employees, investors and shareholders.

Legislation

From the 1970s onwards there have been increasingly tough regulations. Failure to comply with these regulations can lead to prosecution. New legislation is now centralised around take back systems. In these systems the responsibility of safely disposing the product at its end of life is given to the producer. Examples of other legislation already in use are also covered.

Legislation: WEEE

WEEE stands for Waste Electronic and Electrical Equipment, which covers any product containing a plug or battery. This waste often includes chemicals and lead, yet 90% of WEEE is landfilled without proper treatment. The quantity of WEEE within the EU is growing at a rate of 3 – 5% per year. This growth is 3 times higher than municipal (household) waste. The Netherlands, Denmark, Sweden, Austria, Belgium and Italy currently have similar legislation; Finland and Germany are expected to follow soon.

EC Draft WEEE Directive:

- Producers (importers and manufacturers) are responsible for financing the collection, recycling and safe disposal of WEEE.
- The producers would not be able to safely dispose of materials such as lead, cadmium or mercury. The directive therefore bans their use.
- As a result of the directive it will be more financially sound for producers to repair or reuse products rather than disposing of them. This will hopefully encourage companies to design for easy disassembly and recycling.
- A recycling target would be set for the WEEE the producers have collected back from consumers. This would be around 90% by weight of large appliances such as washing machines and 70% by weight for smaller appliances such as hair dryers.
- The producers will be left with the resulting recycled polymer to either use themselves or sell on. This will help to encourage a level of recycled material in new products (national governments would set this level)

Source: Dr Tracy Bhamra *'Ecodesign & Business lecture'* Loughborough University 2001

Legislation: End of Vehicle Life

Two million cars are scrapped in Britain annually. Currently only about 30% by volume of the materials inside old cars can be removed economically, the rest cannot be detached easily enough. EU laws may soon be changed so producers will by law have to recycle every car they have produced. It is

hoped that eventually 95% of a vehicle will be recyclable and the resulting recycled steel and plastic can be used in new products. It is predicted that producers will pass the costs for this through to consumers by increasing the cost of new cars.
The law is still in discussion, as many car producers, such as Rover claims that the law is flawed. Rover claim that recycling every single car they had ever made would cost several hundred million pounds. This cost could financially ruin companies.
Source: Dr Tracy Bhamra *'Ecodesign & Business lecture'* Loughborough University 2001

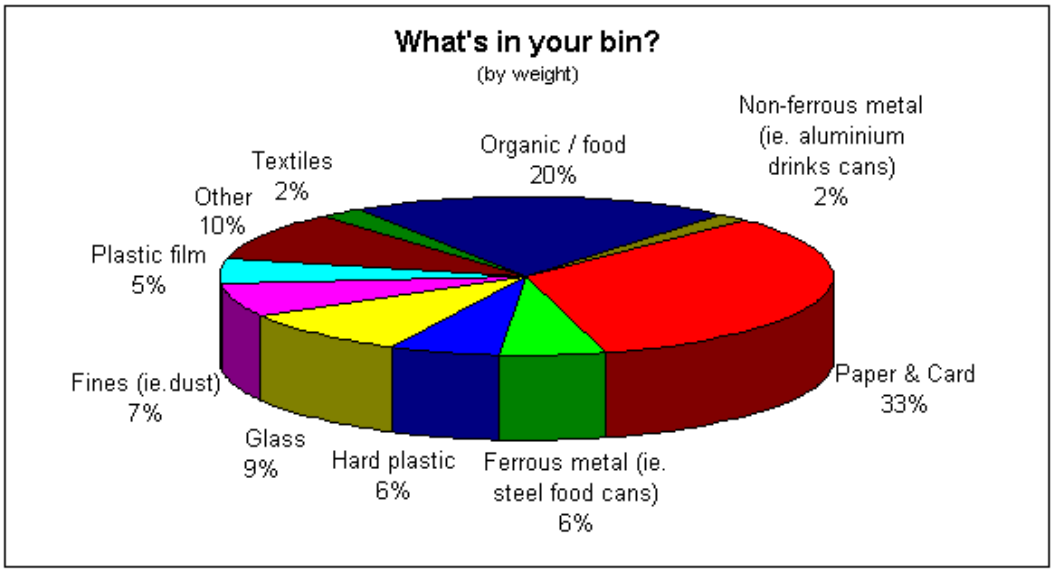
Legislation: The Producer Responsibility Obligations (Packaging Waste) Regulations 1997

By adopting the principle of 'producer responsibility', the UK government has implemented the EC Directive on Packaging and Packaging Waste (94/62). The environmental costs of packaging are placed on those who produce and use it. Currently, this affects only businesses with a turnover of £5 million or more, although this is staggered over time to include smaller operations.
The regulations sets out recovery and recycling targets for manufacturers (6%), converters (9%), packers and fillers (37%) and sellers (48%).
Source: www.wastewatch.com

Legislation: Environmental Protection Act (1990) (including Duty of Care)

This covers the disposal of waste. Section 34, the Duty of Care applies to organisations that generate waste. This applies to everyone who produce, import, carry, treat or dispose of "controlled" wastes, which includes all household, commercial and industrial wastes, liquid or solid. Everyone subject to the Duty of Care must ensure that their waste is kept in a secure container so none can escape and that it is only transferred to authorised carriers.
Source: www.wastewatch.com

Legislation acts to minimise areas like this.
Source: www.demi.co.uk



Source: www.wastewatch.co.uk

Ideally legislation will lead to all of these items being recycled or composted.

Legislation: Landfill Tax Regulations and The Finance Act 1996

On 1 October 1996, a tax of £7 per tonne was introduced for active waste (the majority of waste we produced is active), and £2 per for inactive waste (for example rubble). In the March 1999 budget the standard rate was given a yearly increase, or 'landfill escalator', of £1 per year until it reaches £15 per tonne in 2004. Although the tax is collected from the landfill site operator, the costs can be passed through the collection chain to the companies that actually generate the waste.
Source: www.wastewatch.com

Legislation: ISO Standards

ISO 14001 is the title of an international series of standards which were developed to introduce, establish and provide the means of examining and certifying environmental management systems (EMS) in companies. ISO standard 14001 defines requirements on the EMS. It is intended to enable companies to bring their EMS in line with other international policies and requirements. The standard is meant to be applicable to any company regardless of its size and of geographic, cultural and social conditions. Its overriding goal is to promote environmental protection and to achieve environmental and economic goals.
ISO 14040 is part of the ISO 14000 series, which deals with product life cycle assessment (LCA.) These standards define a uniform structure for an assessment method whose purpose is to facilitate decisions in product and

process development. (LCA is a tool to identify and assess the environmental improvement potential of a product throughout the various phases of its life cycle.) This is achieved by:

- Compiling an inventory of all material and energy flows associated with the product along the entire course of its' life cycle
- Describing potential environmental impacts
- Evaluating the outcome with respect to the goals of LCA

Consideration is given to the product system as a whole.
This level can be very expensive for smaller companies to achieve.
Companies can get publicity by meeting these regulations, however.

Source: Ursula Tischner, Eva Schmincke, Frieder Rubik, Martin Prosler '*How to do Ecodesign?'* Verlag form praxis, 2000

2.2 REDUCE

Design can help to directly reduce environmental impacts by making reductions throughout the whole products' life cycle:

Reduce: material extraction

Recycled or reclaimed materials could be used to eliminate environmental problems resulting from extraction. There are also alternatives to oil based plastics:

"ECO-FOAM starch based packaging materials are made from a renewable resource – corn.
• Completely biodegradable and dissolves in water.
• Naturally static free and reusable, unlike plastic which is made from oil.
• Water soluble so disposal couldn't be easier, it even makes great compost. "
Source: www.demi.org.uk

Bioplastics are plastics made from plants, usually polymers of starch or polylactic acid (PLA). They are being used for bags, cutlery and plates, pens, clothing, credit cards, food packaging, agricultural films, teabags, coffee filters, diapers and napkins.
The main brands of the plastic itself are: Biopol, Bionolle, NatureWorks and Mater-Bi. These plastics are cyclic in their sourcing, with starch coming from plants, particularly in Europe where the "starch mountains" some years ago prompted the research that led to the development of starch plastics. It is also possible to make PLA from milk residues and even household waste.

Barbie may soon be produced from bioplastic! The company intends to begin the introduction of products produced from organically derived materials. As the viability of these new technologies is confirmed, their use will be expanded into all brand categories and product lines. In Barbie's 2000 campaign to be President, she said, "It's time we take a stand to care for Mother Earth. Clean air, clean water and a clean environment are vital to our health."
Source: www.biothinking.com

There are environmental problems with both disposable and reusable cotton nappies.
Source:
www.yummiesnappies.co.uk/WhyCotton.html

In terms of material extraction and disposal alone it is thought to be better on the environment to use reusable cloth nappies instead of buying many disposable nappies. In terms of extraction: four and a half trees are destroyed to keep one baby in disposable nappies. In terms of disposal: disposable nappies have chemical granules inside them that can absorb many times their own volume in liquid - this material was not designed to be disposed of untreated into a landfill. A reusable nappy has none of these problems.
Source: www.yummiesnappies.co.uk/WhyCotton.html

Regardless of what type of nappy is used it is impossible to avoid some impact on the environment. Reusable cloth nappies require large quantities of electricity for washing and drying plus significant water use and chemical usage in the form of pre-wash soakers and detergents. www.thenappylady.co.uk/htm/environmental_costs_of_disposables.htm suggests that this does not outweigh the problems associated with disposable nappies, however: “It takes as much energy to make one disposable nappy as it does to wash a real nappy 200 times.”

Reduce: manufacture

Making production as energy efficient as possible and reducing material wastage reduces the environmental impact and saves the company money.

One way of making production more efficient is by using good design to reduce the number of components that assemble into a product. Each component is produced separately by a machine that requires energy to function. Reducing the number of components therefore reduces the number of machines operating. This reduces energy usage and also removes the

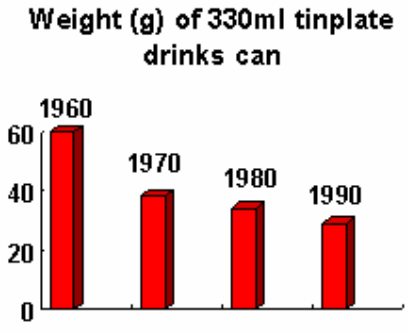
environmental damage caused by the production of the machine and its associated tools and moulds.

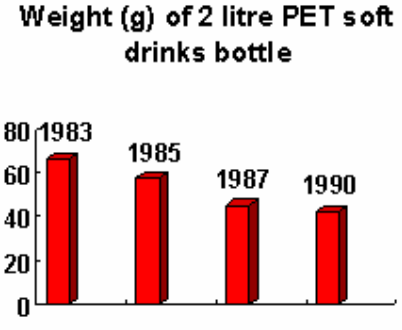
Ford at their Bridgend, Wales factory have installed $2.3m worth of solar panels. The panels are 'solar skylights' that not only contribute to the plant's power and lighting requirements, but also allow natural daylight to reach the workspace. Covering 25,000 square metres of the plant's roof, 26 solar units (incorporating 1540 photovoltaic cells) have been installed. This 97 kW system provides all the lighting requirements for the building beneath.

Source: www.biothinking.com

Reduce: Material Use

There are several steps that manufacturers can take to reduce the amount of material used in a product or its package. One way is as subtle as “lightweighting” and therefore it often goes unnoticed to the general public. Lightweighting simply means using a different lighter resin mass or reducing the wall thickness to produce the same thing.
A 2-litre plastic soft drink bottle used in the 1970s had a mass of 67g. Today a soft drink bottle weighs 47g.
Plastic grocery bags have been reduced in thickness by over 1/3 between 1976 and 1990 without loss of strength





Two examples of lightweighting over time are shown in these graphs.
A 2-litre plastic soft drink bottle used in the 1970s had a mass of 67 grams. Today a soft drinks bottle weighs 47 grams.
Another example of successful lightweighting is found in plastic carrier bags. Their thickness has been reduced by a third between 1976 and 1990 with no loss of strength.

- Manufacturers can also offer concentrated forms of their products which occupy less space and require less packaging.

Designers can substitute hazardous materials. This cardboard chair by ReturDesign and the Rondine armchair by Totem Italia both avoid the use of glues with their clever joint construction.
Source: www.biothinking.com

The Tripp Trapp Chair grows with the child, meaning you don't end up with a baby chair you can't use anymore. This increases the life span of the product, preventing the wastage of material producing bigger replacement chairs.
Source: www.biothinking.com

Trannon make all their furniture from British hardwood grown less than 50 miles from their factory, and they use only the thinnings -- narrow wood that is cleared to make way for bigger trees and which is usually wasted.
Source: www.biothinking.com

The networked bookshelf allows users to download books at their wish. Touch-screen interactive books recharge on a bookshelf containing a network linked printer. This example of dematerialization drastically reduces material usage and distribution.
Case study by Chris Sherwin, Philips Environmental Service
Source: www.demi.org.uk

Reduce: transportation

The Soft Air company have updated the Sixties notion of inflatable furniture. By shifting emphasis towards practicality, this method of reducing materials and transport costs is now taken seriously by retail giants IKEA and MUJI
Source: www.demi.org.uk

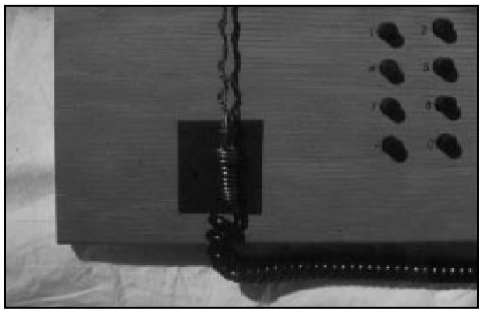


Figure 8: Plaine Telephone – detail of keys

Plaine Telephone by Stuart Walker is designed for ease of manufacture with basic equipment. The electronics are all off the shelf parts.
The telephone could therefore be manufactured locally, reducing transportation. Local repairs and reuse of parts at the products' end of life are also encouraged by local production.

Source: JSPD e-journal www.cfsd.org.uk/journal

Reduce: water

'Smart sink' has a membrane bowl, which expands and contracts as needed to minimise water use. It also controls, calibrates and purifies water and gives feedback on rates and levels of consumption.
Source: JSPD e-journal www.cfsd.org.uk/journal

Reduce: energy

The Citizen eco-drive duo watch is powered by a mixture of solar power and kinetic movement.
Source: www.biothinking.com

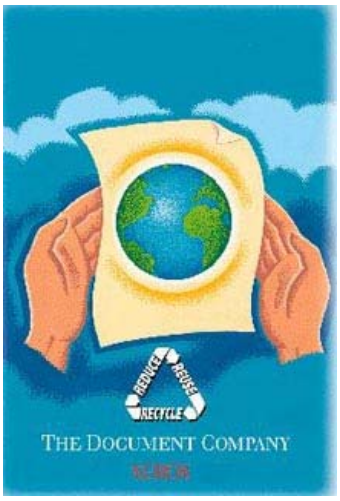
The VW Lupo TDI gets 98 miles per gallon. Run it on biodiesel fuel and you have a very efficient, solar car.
Source: www.biothinking.com

Successful for its high media profile and wider social aims, the Baygen/Freeplay wind-up radio demonstrates that appropriate technology can address social as well as environmental problems
Source www.demi.org.uk

2.3 REUSE

Reuse of a product or of a component for its original purpose
This has been done for many years with milk bottles – but why not for plastic bottles? People often obtain their vehicle spares cheaply from scrap dealers. However, people may feel uncomfortable buying a new car knowing that the seat cushions had been used before. Designs incorporating re-use therefore have to make sure the public will accept them.

Detergent companies carry out a widely accepted reuse programme. Consumers can buy cheaper pouches of detergent to refill the original bottle.



Photocopiers are leased to customers and maintained by Xerox. When their service is no longer required the products are taken back, refurbished and hired (or resold) to customers for second, third and further uses. Refurbished products pass through the same assembly line as new products and are subject to the same stringent quality tests. The company is still able to maintain control over the complete manufacture, distribution and take-back of the product. When products cannot be refurbished, parts are reused or materials recycled in new products.
Source: www.demi.org.uk

Charity shops are very successful at reuse. They collect and sell unwanted items such as clothes, toys, gifts, books and furniture.
Source: www.wastewatch.co.uk

Secondary Use

Use of largely unaltered products for a purpose different than the first.
Two examples of 2nd year Industrial design and technology projects from Loughborough University.

The students designed ways of transforming irreparable mail bags into new products:

Third World Mosquito net by Damian Blanchard, David Hagelthorn, Mark Hirst and Christopher Mills
Bags could be stitched together using strips from a plucked bag and made to provide protection against the biggest killers in Africa.
The bags could also be reused to fence in chickens or make partitions, which would save wood.

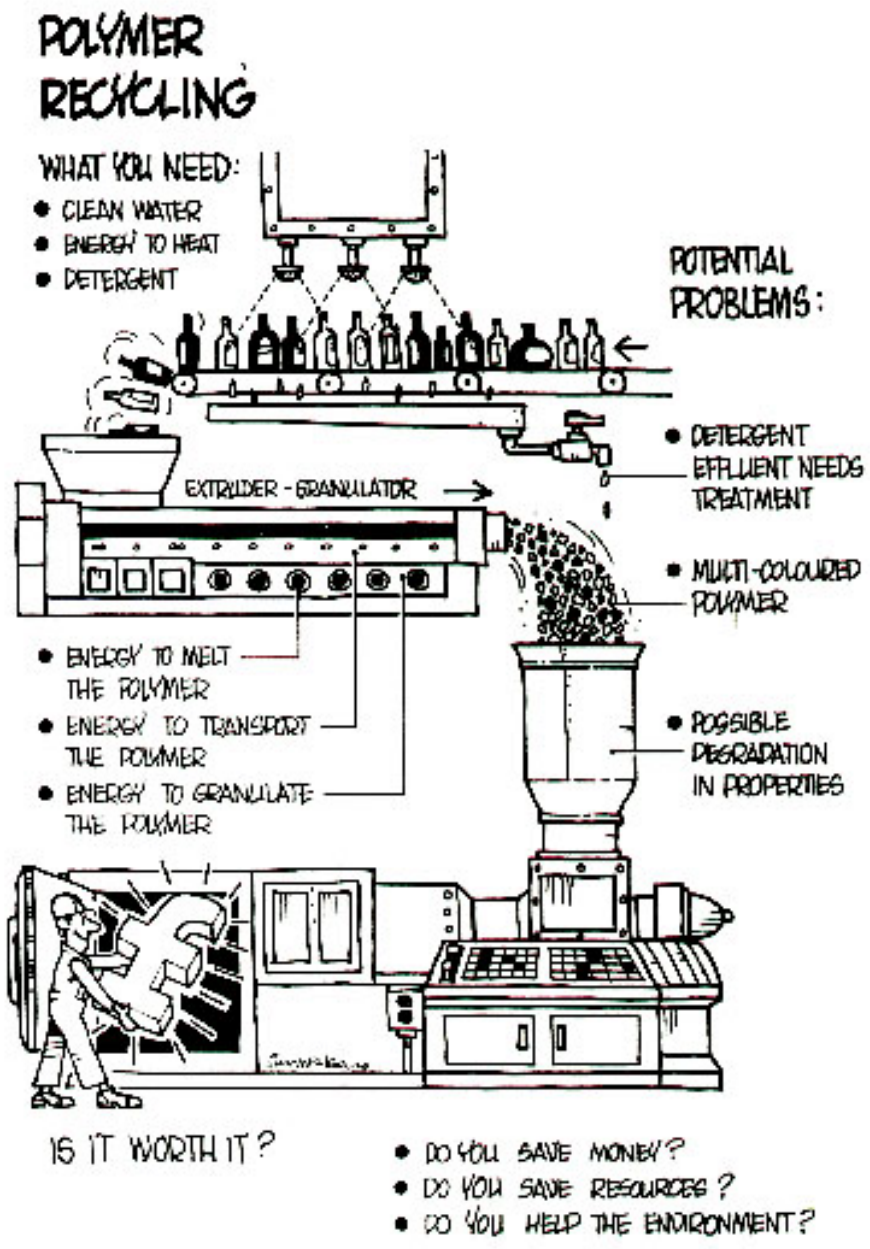
The post jacket by James Partridge, Graham Randall, Lindsay Patmore and James Whitehead.
The bags are used as insulation in jackets. The product was designed so it could be used by the Royal Mail. This would mean a market would not have to be found for the product.

The Earthchair is supplied as an empty sack, which the user stuffs with plastic bags. This interactive approach to waste helps communicate the environmental message to consumers.
Source: www.biothinking.com

Aluminium 'Curva' ruler, developed by the Dutch company De Denktank.
Made from the blade of a used and discarded aluminium blind. Blinds from an aluminium tip are disassembled, cleaned, cut to shape and printed. The ruler is indestructible and can measure curved contours. The reuse extends the life cycle of aluminium, which is a very energy-intensive material to extract from the earth.
Source: How to do EcoDesign? By Tischner *et al*

2.4 RECYCLING

An overview of the process:

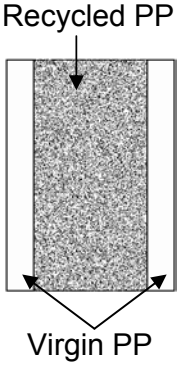


Source: Dick Heath 'Recycling plastic and rubber' *New Designer*, Volume 1, Issue 1, September 1995

How people respond to recycled materials (taken from www.wastewatch.co.uk):

"Myth: Recycled products are poor quality.
Reality: False. Aluminium and glass can be recycled repeatedly without a loss in quality. Paper does suffer a reduction in quality as paper fibres shorten with each reprocessing which limits the number of times it can be recycled. But high quality paper is readily available and lower grades of paper are suitable for many uses. Throughout the world, military and commercial aircraft use retread tyres, as do time-critical courier services such as Federal Express.
Myth: Recycled products are too expensive.
Reality: Recycled products should not cost more but for some product areas economies of scale do result in higher prices. That is why creating consumer demand is so important to help lower prices.
Myth: Recycled products are not attractive.
Reality: Gone are the days of grey and grainy recycled paper. For many items it is impossible to distinguish between recycled and non-recycled items.
Myth: Recycled products consume more energy and resources than a product made from primary materials.
Reality: False. Many recycled materials offer significant savings in terms of energy and water as well as reductions in resource use. For example, manufacturing 1 tonne of recycled paper results in 74% less air pollution and 34% less water pollution than manufacturing a tonne of paper from virgin wood pulp… Negative experience in the past with recycled products reinforces the inertia. The view that "we have always bought that product, so why change now?" is commonly expressed. Combating these myths and prejudices…can be accelerated through the provision of accurate information, good practice case studies, demonstration projects and a supportive national framework."

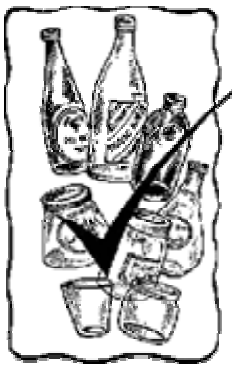
Plastics have a maximum recycled polymer content. This content will be smaller for more structural items such as furniture and bigger for items such as plastic bags. This is because the recycled polymer may be slightly contaminated. Also, as the polymer is recycled its' properties will be changed by the process. If too much recycled content is used fatigue can lead to the material breaking. Sometimes legislation will state that recycled plastic has to be laminated with a layer of virgin plastic. This often occurs in food packaging.



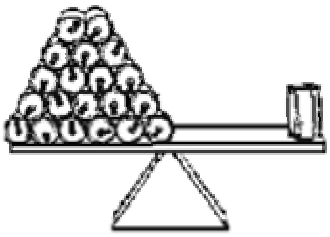
There are two types of recycling: closed loop and open loop. For closed-loop recycling the producer has to collect the products when they are due to be thrown away. This can be done through good consumer collection strategies, for example renting the product or giving the consumer money for the products' return. A more popular route involves recycling the waste produced during the manufacturing process. Production waste, for example faulty mouldings, offcuts or flash that may have to be cut off each product when it is removed from the mould, is easily collected. The producer can then recycle the collected polymer and use the resulting recycled material to produce the same product. Open-loop recycling uses recycled material gained from a variety of sources such as recycled polymer sheet suppliers or through municipal waste. The recycled polymer is then used to produce new unrelated products.

Material Recycling - Closed- Loop Recycling

Factories will often recycle plastic that is wasted due to problems such as flash or runners produced during component production.
Other examples include:



Use of waste glass for glass production.
Source:
www.ecorecycle.viv.gov.au/aboutus/infosheet_glass.asp

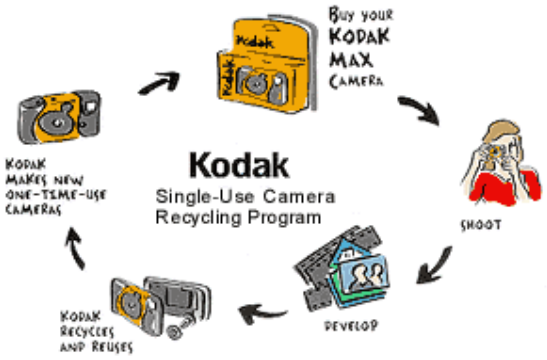


Aluminium can recycling.
The energy required to make one new aluminium can is the same as the energy needed to recycle twenty aluminium cans.
(adapted from Alcoa Australia)
Source:
www.ecorecycle.viv.gov.au/aboutus/infosheet_aluminium.asp

Paper, steel cans, milk and juice carton and plastic recycling are also very popular.

Many businesses also directly recycle their products at their end of lives: "Canon Business machines began recovering its more than 20 million used laser-printer toner cartridges by working with a national delivery service to develop a U.S. collection system. Cartridges are disassembled and combined

with virgin material to produce new units. GE Plastics buys back plastic material in flake or pellet form, provided it is processed by acceptable regrind specifications and procedures…" (Machine Design, Feb 1993.)

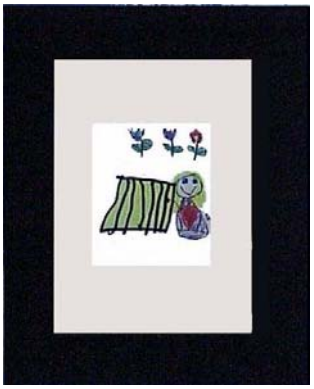


Kodaks' once disposable single-use camera is reused and recycled when returned for photo development.

Source: www.kodak.com/US/en/corp/environment/performance/recycling/suc.shtml

Material Recycling – Open-Loop Recycling

YEMM & HART
GREEN PRODUCTS
1417 MADISON 308 MARQUAND MO 63655-9153 USA
TEL 573-783-5434 FAX 573-783-7544



Yemm+Hart are primarily a supplier of recycled sheet materials. They have used their own sheets to produce products such as CD storage boxes, clipboards and cutting boards from recycled polymers. They use the multicoloured 'speckled' qualities of the material to add to the aesthetic qualities of the design. They also recycle more unusual materials; the picture frame above right is laminated with recycled worn out car tyres.
Source: www.yemm+hart.com

Smile Plastics is their UK competitor. "Smile Plastics is committed to sourcing and developing innovative ideas and markets for recycled materials, concentrating on transforming plastics waste into multicoloured sheets."

Examples of recycled materials can be found on their website (http://www.smile-plastics.co.uk)

Coffee table by James Oswald

Material: recycled HDPE made from disposable coffee cups.
Material selected for: aesthetic purposes.
Processes: cutting and routing.

"The design of a small coffee table using recycled polymers in a subtle and elegant manner. The design aims to combine the visual qualities of the glass with the striking pattern of the recycled polymer. The elliptical form is followed throughout the design creating a uniform feel to both materials."
Taken from 2nd and 3rd year student work designing with recycled polymers from Made of Waste Ltd

Composting:

Composting your food scraps and garden trimmings reduces the amount of waste that needs to be disposed of. It also provides you with free rich soil that would otherwise have to be transported to your house. Using compost can also greatly reduce the need for water, fertilisers and pesticides.

Symphony Environmental has developed a material that is inherently degradable (using unique EPI® DCP® (degradable additive) technology.) This solves the environmental problem caused by the 80,000 tonnes of waste polythene generated from refuse sack production...in the UK alone.
Source: www.demi.org.uk

IDRA student first place 2001
Jason Iverson and Shayan Rafie
University of Washington Industrial Design Dept.

"The Compostable Keyboard", computer keyboard made of carrot pulp, keys of spinach and celery. In nature, all waste converts to food. Product wants commercial production and product consumption cycles to evolve to be as efficient as nature.
Source: www.designresource.org.uk

The Synchilla fleece top by Patagonia is made from recycled plastic bottles.
Source: www.biothinking.com

The Remarkable Recycled Pen is made from a single plastic coffee cup. It also lasts four times longer than most other ballpoints.
Source: www.biothinking.com

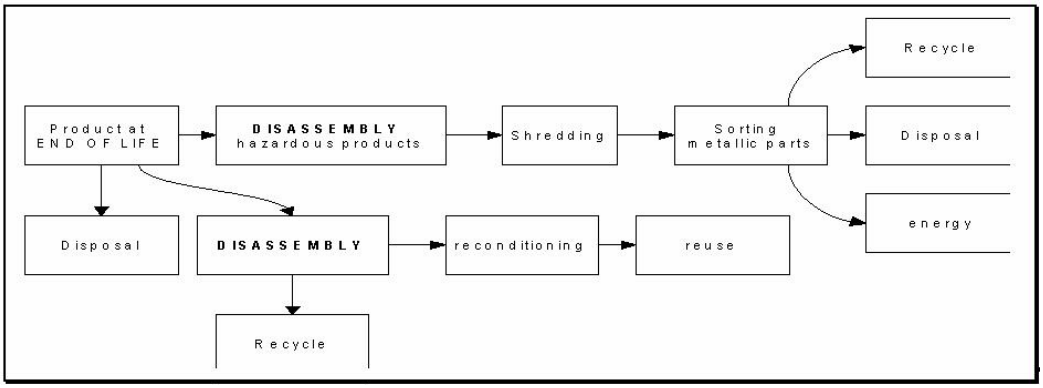
Seventh generation 2-Ply Toilet Paper is made from 80% post-consumer and 20% preconsumer recycled paper.
Source: www.greenhomes.com

Artisan-made, recycled glassware.
Source: www.greenhomes.com

Rustic Bowl, handcrafted from recycled metal.
Source: www.greenhomes.com

Disassembling products for recycling

What can happen at a products' end of life:



Source: http://greenmfg.me.berkeley.edu/green/cad/ametide

The diagram above shows how important ease of disassembly is to ensuring products are recycled or reused rather than going into 'disposal,' i.e. landfill or incineration. Products should be made from fewer polymer types to aid sorting and fewer components to aid separation. The automotive industry is now leading the way by using fewer plastic types in cars.

The Louis 20 chair by Philippe Starck is made from only aluminium and polypropylene, both over 99% pure. The chair is held together with only five screws, making it very easy to disassemble and recycle.
Source: www.biothinking.com

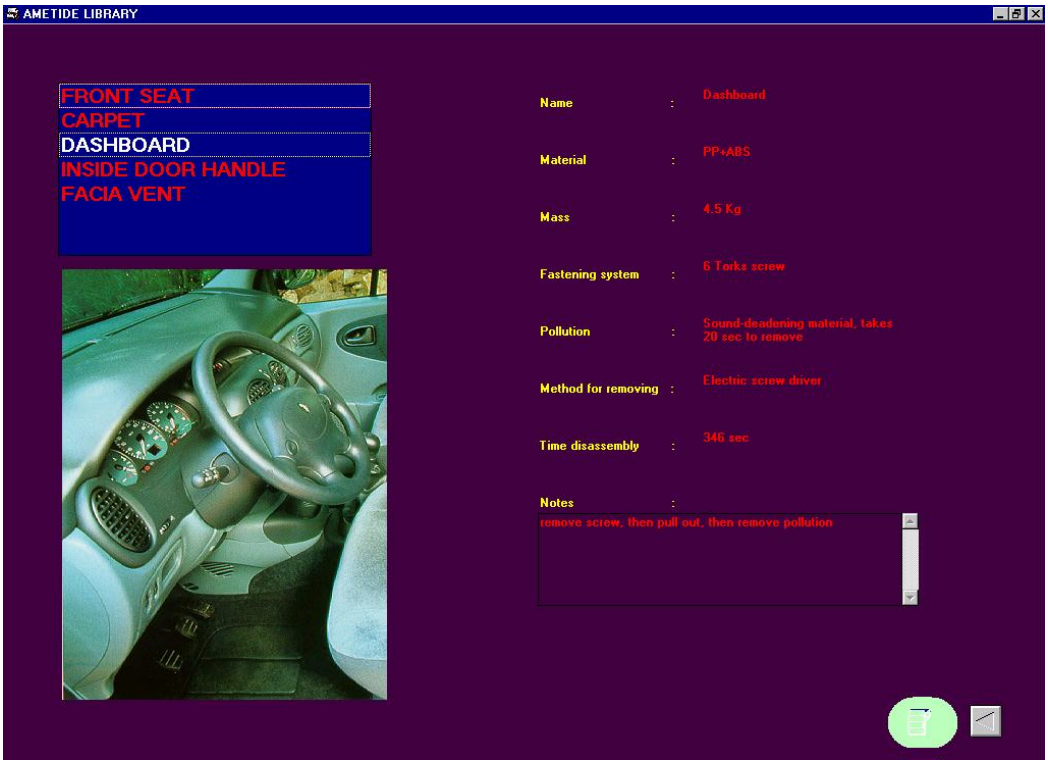
Disassembly computer aids

Ametide – A MEthodology for TIme Disassembly Estimation. In association with Renault, the consortium on green design and manufacturing and 3S:

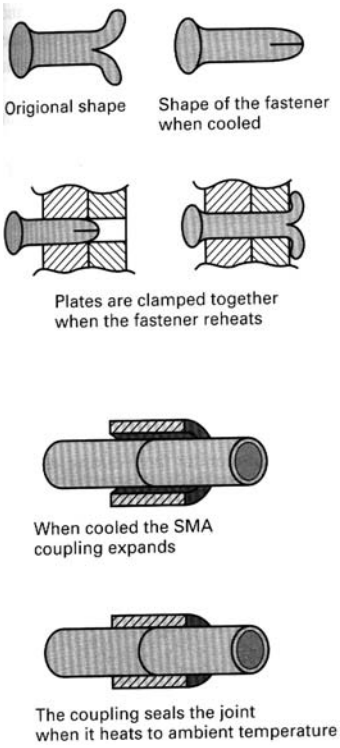
"Given that disassembly techniques, which include a lot of destructive methods, are improving all the time, we assumed that designer has no time to update his knowledge in disassembly. To prevent this we set up a database easily updated from where we extract all the disassembly techniques

available corresponding to a fastener. Thus the designer get the panel of all possibilities for removing a part and can choose which is the best depending of what the part is disassemble for."

A typical screen from the programme. Gives component name, mass and material type; the fastening system used; pollution; method of disassembly and disassembly time:
Source: http://greenmfg.me.berkeley.edu/green/cad/ametide



SMART materials



A technological solution to the disassembly process is the use of shape-memory alloys (SMAs.) These can change shape at specified temperatures. Some types can also create force when they change shape. This force can be used to give 'active disassembly' where the SMAs force different components out of the assembly at different temperatures. More information on this technique can be found in the Inspirational current work section by Pete Simmons.
Source: Norman, Cubitt, Urry, Whittaker '*Advanced Design and Technology'* Third Edition.

2.5 DISASSEMBLING AND ANALYSING PRODUCTS

Find a broken/unused product from your home or buy one from a charity shop. Try to disassemble the product into its individual components. Electrical parts such as plugs and motors do not have to be disassembled. These components would be designed by engineers and are likely to be supplied as off the shelf parts. Make notes as to how the product was disassembled, how difficult and time consuming it was and if possible take pictures. Number and name each component, filling in the table found at the end of this section may help. Some material and processes identification help and common problems to look out for in the exercise are included next.

Identifying polymers

Polymer codes

Table 1. MAJOR PLASTIC RESINS AND THEIR USES

Resin Code	Resin Name	Uses	Recycled Products
1	Polyethylene Terephthalate (PET or PETE)	Plastic soft drink bottles, mouthwash bottles, peanut butter and salad dressing containers	Liquid soap bottles, strapping, fiberfill for winter coats, surfboards, paint brushes, fuzz on tennis balls, soft drink bottles, film, egg cartons, skis, carpets, boats
2	High Density Polyethylene (HDPE)	Milk, water and juice containers, grocery bags, toys, liquid detergent bottles	Flower pots, drain pipes, signs, stadium seats, trash cans, recycling bins, traffic-barrier cones, golf bag liners, detergent bottles, toys
3	Polyvinyl Chloride (V)	Clear food packaging, shampoo bottles	Floor mats. pipes, hose, mud flaps
4	Low Density Polyethylene (LDPE)	Bread bags, frozen food bags, grocery bags	Garbage can liners, grocery bags, multipurpose bags
5	Polypropylene (PP)	Ketchup bottles, yogurt containers and margarine tubs, medicine bottles	Manhole steps, paint buckets, videocassette storage cases, ice scrapers, fast-food trays, lawn mower wheels, automobile battery parts
6	Polystyrene (PS)	Videocassette cases, compact disc jackets, coffee cups, knives, spoons, and forks, cafeteria trays, grocery store meat trays and fast-food sandwich containers	License plate holders, golf course and septic tank drainage systems, desk top accessories, hanging files, food service trays, flower pots, trash cans, videocassettes

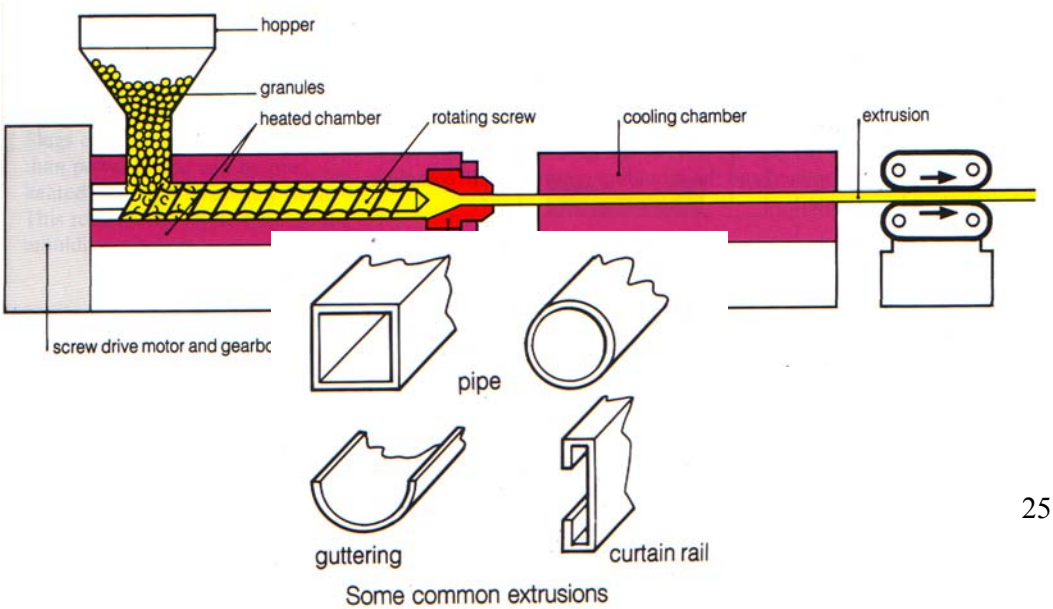
Source: www.plastics.ca/StaticContent/StaticPages?teachers/pdf/background.pdf

Some polymer characteristics

Plastic	*Density compared to water*	*Characteristics*	*Applications (if not included in above table)*
PET	Sinks		
HDPE	Floats	Fairly stiff, strong resistant to chemical attack	
LDPE	Floats	Weaker, softer and more flexible than HDPE	
PP	Floats	Tougher and more rigid than HDPE. Very low density. High impact strength. Used for 'live' plastic hinges as can be flexed thousands of times without breaking.	
PS	Sinks	Solid – very brittle. Metallic ring sound when dropped Expanded – soft and spongy	Medicine spoon EPS disposable cups
Acrylic		Can have glass-like transparency. Very brittle - easily scratched/cracked	Watch 'glass' Car light units
Nylon		'solid' nylon used for its low frictional properties – usually creamy white colour. Can also be used as a fibre.	Fast moving parts such as gears or bearings. Fibre form: toothbrush bristles
PVC	Sinks	Stiff hard wearing Add plasticiser – more flexible and rubbery	Drain pipes Cables will be coated with flexible PVC 'leathercloth' car seats

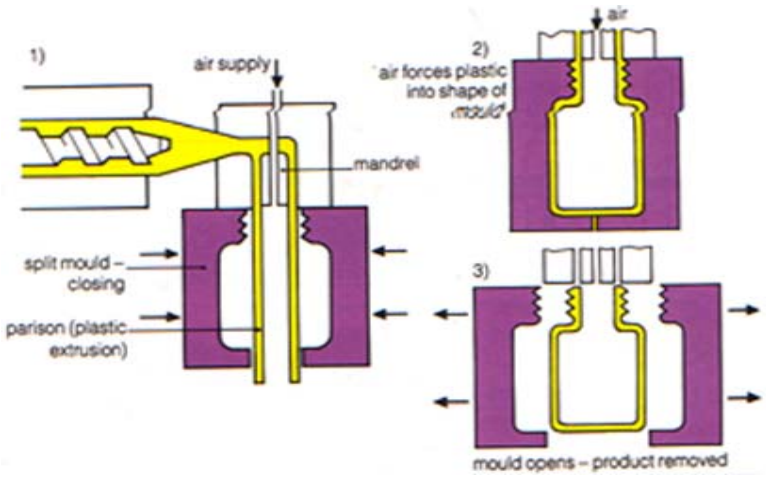
Common processing routes for plastics

Extruded – 'long' products such as drain pipes and curtain rail. Molten plastic is forced through a die, which contains a hole whose shape corresponds to that of the required article. The extrusion will then be cut into lengths. The cross section will be the same along the length. Used with plastics such as polythene, PVC and nylon and also metals.
Source: James Garratt '*Design and Technology'* Cambridge 1994

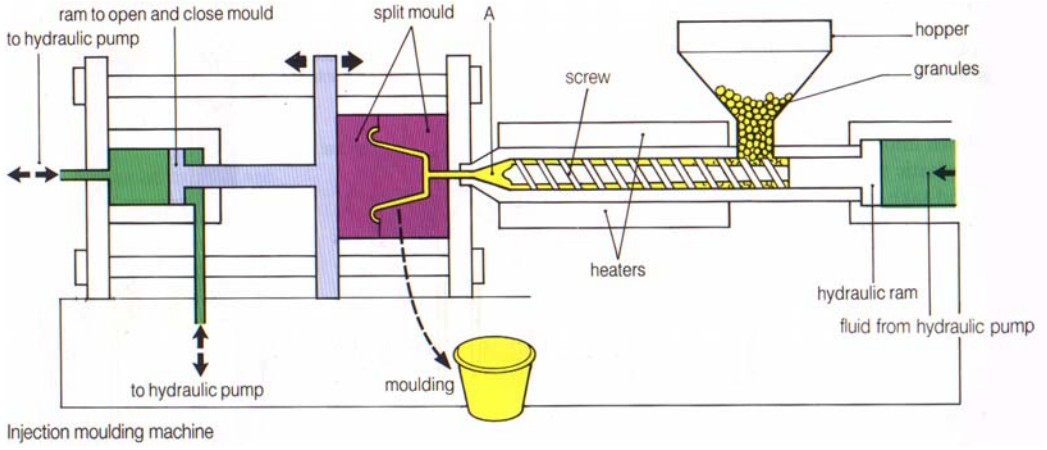


Some common extrusions

Extrusion blow moulding – bottles and hollow toys. Air is blown into a section of extruded plastic tube (parison) causing it to expand and take up the shape of the mould. Should have split line on both sides along length where the two sides of the mould came together. Will be one mark at centre of bottom where the parison (plastic extrusion) fed into the mould is cut off. PVC, polythene and polypropylene are common blow-moulding materials.
Source: James Garratt '*Design and Technology'* Cambridge 1994

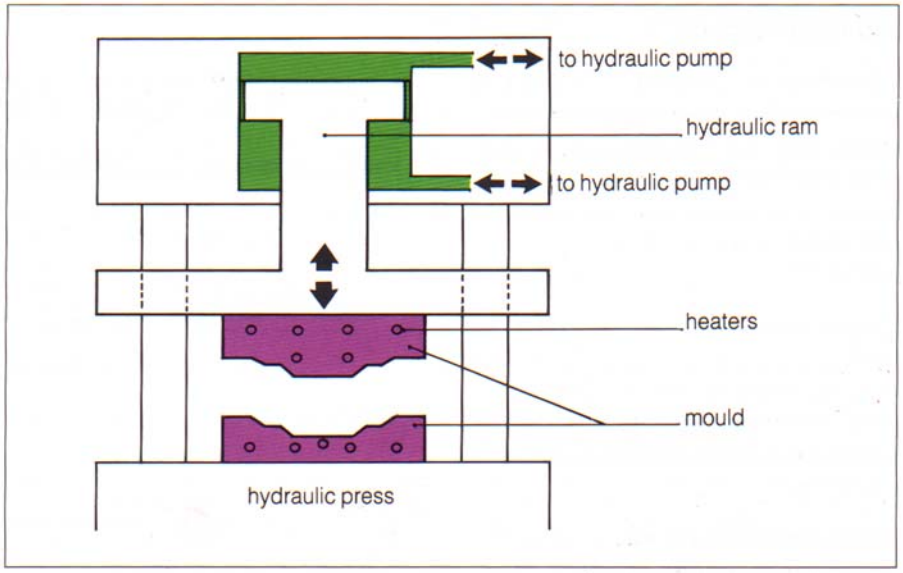


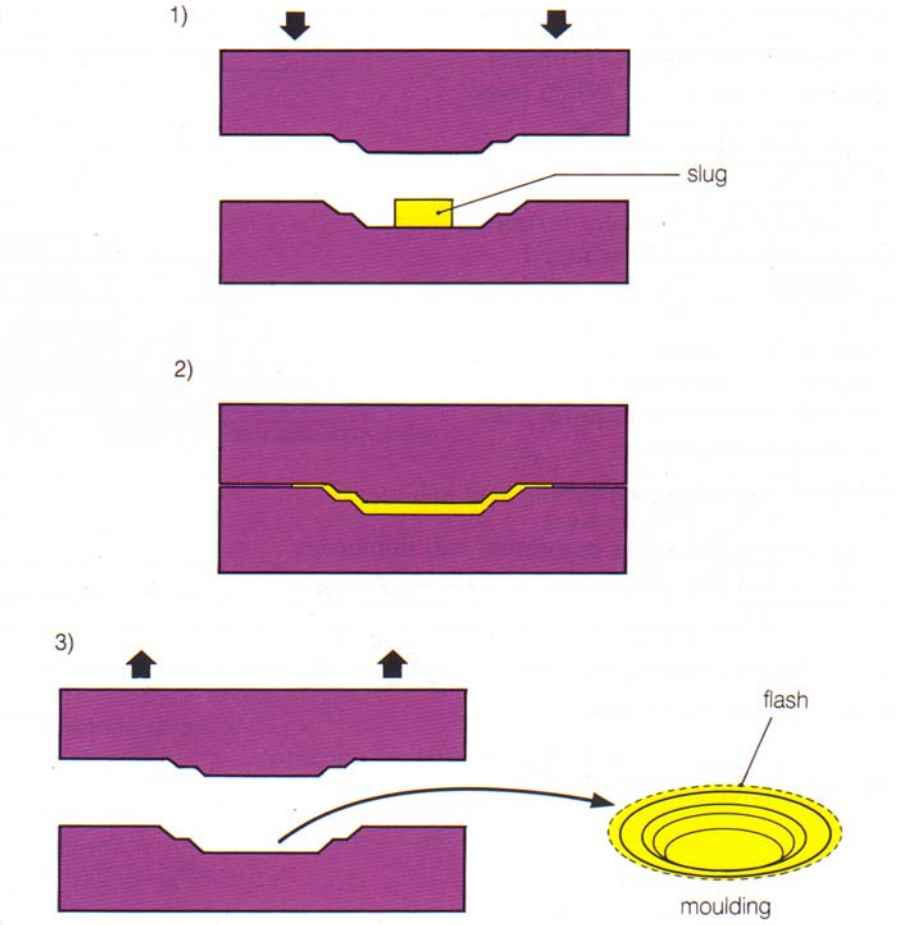
Injection moulding – cases for electrical appliances, toys and games, products for the car industry, kitchenware such as bowls and containers, often relatively complex forms. Molten plastic is forced into a mould. The mould consists of two or more parts that fit together, forming a cavity of the required shape. Should have one rough 'gate' mark where the polymer is injected into the mould. There may be several smooth circular marks caused by ejector pins pushing the component out of the mould. Polythene, polystyrene, polypropylene and nylon are typical injection moulding materials.
Source: James Garratt '*Design and Technology'* Cambridge 1994



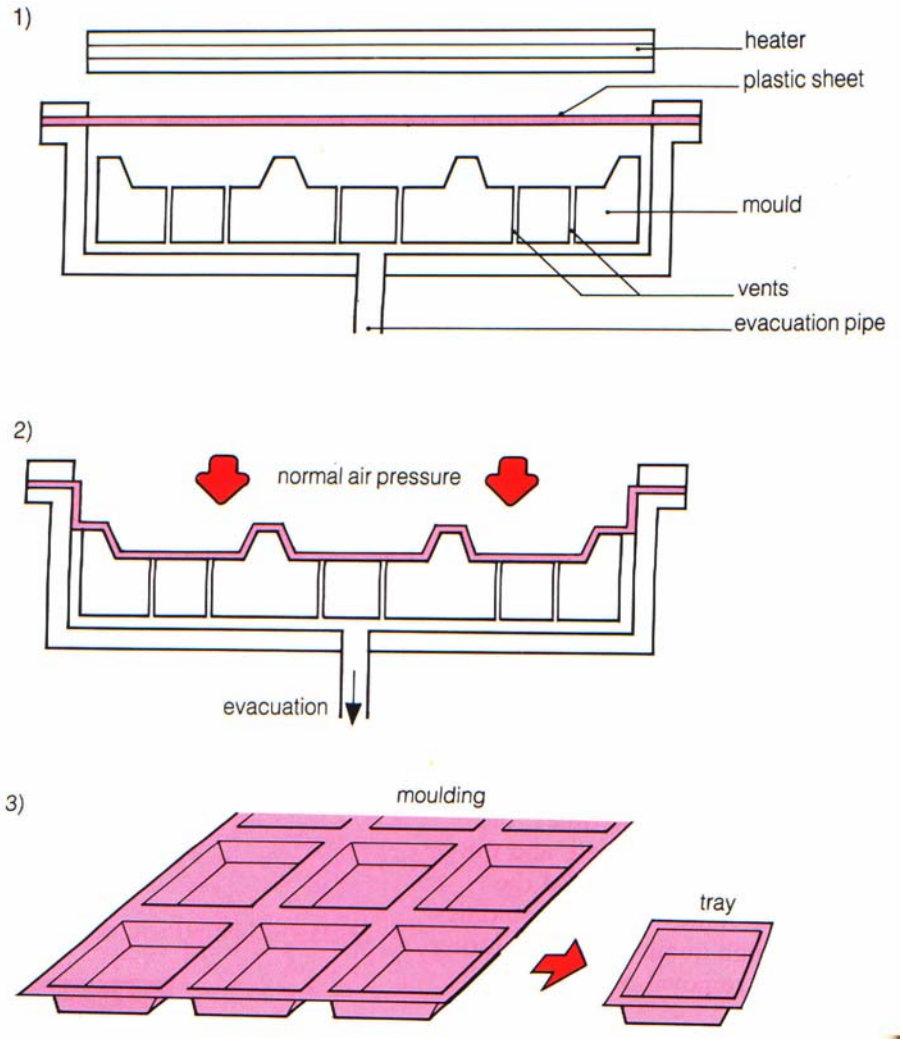
Compression Moulding – electrical fittings such as plugs and sockets, saucepan and cutlery handles, bottle tops and toilet seats. A measured quantity of polymer is squeezed into shape between heated moulds. The

mouldings have a high quality finish requiring only the removal of 'flash.' Compression moulding is usually used for thermosetting plastics such as phenol, urea and melamine formaldehyde.
Source: James Garratt '*Design and Technology'* Cambridge 1994





Vacuum Forming – chocolate box liners, egg boxes, seed trays, shop signs and fittings, some motor car dashboards, wash basins and baths. Mainly for shallow components made from thin sheet. A sheet of polymer is heated until soft and rubbery. The air is then evacuated from beneath the sheet. This allows the normal 'outside' air pressure to push down on the softened sheet, forcing it to take up the shape of the mould. Acrylic, polystyrene and PVC are typical vacuum forming materials.

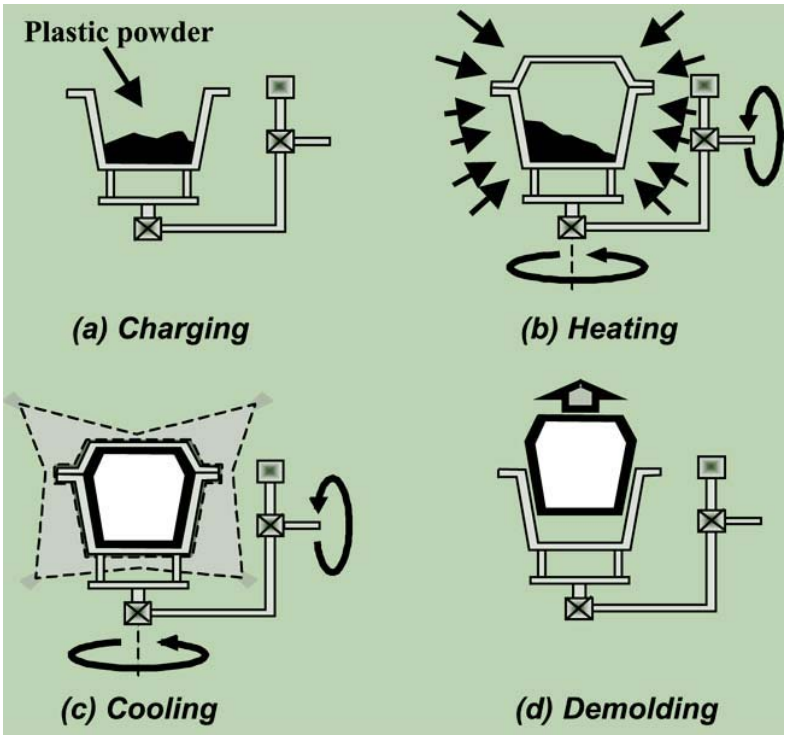


Source: James Garratt '*Design and Technology'* Cambridge 1994

Rotational Moulding -
Rotational moulding is a method for manufacturing hollow plastic products. It is best known for the manufacture of tanks, but designers all over the world are starting to realise that it can be used to make many different types of plastic parts. Some of the sectors that it services include medical products, consumer products, agricultural and garden equipment, automotive and transportation components, toys, leisure craft and sporting equipment, furniture, materials handling articles and highly aesthetic point-of-sale products.

An overview of rotational moulding:

A hollow mould is filled with a powder resin and then rotated bi-axially in an oven until the resin coats the inside of the mould and cures. The mould is then cooled and the part removed. (Source: http://www.rotationmag.com/article3.htm)



Rotational moulding can produce large hollow items, such as fuel tanks. Source: www.rotationmag.com/article3.htm

Calendaring – process used to produce plastic bags.

Expanded Polystyrene Production – Polystyrene beads are expanded to about 40 times their original size using pentane as a blowing agent. They are then heated with steam inside a mould. The final expansion takes place and the beads coalesce to give a shaped moulding.

(For information concerning manufacturing, fabrication and finishing processes for other materials, please refer to pp 264-333
Eddie Norman, Jay Cubitt, Syd Urry, Mike Whittaker, *Advanced Design and Technology,* Third Edition, Longman, 2000)

Potential eco-design problems to look out for and some possible design solutions

If sticky labels are not removed they can contaminate the resulting polymer

Could use indented lettering

ABS

PP

Two different materials are used for the main casing. When disassembled the two parts would have to be separated and recycled individually.

If possible use the same type of polymer throughout the design

Have snap fits been used?
Snap fits can mean a reduction of material usage as screws and glues are not required. Snap fits are easy to assemble as they simply push together. They do not require special tools for disassembly. They can hinder disassembly, however if they are difficult to push back out of place.

Force required to disassemble snap fits can be changed using design, namely the material thickness used. Alternately could be easier to screw together or use active disassembly methods.

Have all components been labelled with their material type? These are usually found as indents, often found inside the casing. Without these labels people will not know how to recycle the components.
Indent recycling aids into all components

Double or 2-shot or co-injection moulding combines two plastic materials by injecting them separately into the mould to form a single part with two visible colours. Co-injection moulding is only possible with polymers that have good adhesion properties. This implies compatibility for recycling. Environmental problems occur, as the two materials co-injected are often different polymers that cannot be recycled together.

This toothbrush has been co-injection moulded. Two different materials that cannot be recycled together are now permanently bonded, making disassembly near impossible.
Different coloured components could slot together. Use different colours of the same material?

Table for recording the disassembly of a product

#	Component name	Material	Surface finish	Processing route	Method of Disassembly
ex.1	Bottom casing	ABS	Green pigmentation	Injection moulded	Snap fits to top casing – levered apart with screwdriver
ex.2	Packaging	Expanded polystyrene	N/a	Expanded and injection moulded	N/a
ex.3	Packaging	Cardboard	Colour Screen Printing	Stamped out of sheet. Folded and glued together with hot glue gun	N/a
ex.4	Cable grip	Copper	N/a	Stamped out of sheet	Screwdriver used to unscrew 2 screws from top casing