



Materials

3.3 Materials

Key Findings

- There is a level of material dependence to the Australian economy that is as high as at any time in history. This is despite the technological advances that have disassociated a large proportion of the world's population from direct involvement in the primary industries—the industries from which all material products originate.
- While monetary flows in the economy are well accounted for, most physical flows are poorly understood. Accounting for the physical dimension of material flows would enable greater appreciation of the fundamental dependence of the economy on materials and of the opportunities for reducing their environmental impact.
- Partly due to significant exports, Australia's total material requirement is increasing, and is currently estimated at 180 tonnes per person per year. This is more than twice that of other OECD countries.
- Over the last quarter century, material flows in the minerals, forestry and agricultural industries have continued to increase, while material flows from fisheries have declined.
- In Victoria, material flows in construction have grown by an estimated 600% between 1946 and 2004 and by 19% between 1984 and 2004. The size of houses has grown throughout the 20th century, while the number of people per house has declined by 40%.
- The increasing production of materials can have an impact on natural systems. For example, previous fishing regimes have reduced the population of Southern Rock Lobster to approximately 20% of the 1951 level.
- Increasing material flows requires significant investments of energy and water. Transporting a kilogram of bananas to Melbourne emits over half a kilogram of CO₂ and the manufacture of approximately half a litre of milk requires 795 litres of water.
- It is estimated that in 2005–06, 32% of the total streamflow in Victoria was harvested. Of this harvested water, around 40% (2,000 GL) is 'exported' out of the state as embodied water, mainly in food products.
- Recycling of material has increased, with 60% of waste diverted from landfill. However, in the period 1993–2006, total material outputs (waste and recycling) per person doubled. The main reason for the increase is the increase in total material consumption, driven primarily by economic factors (including higher incomes).
- 77,000 tonnes of prescribed manufacturing waste were generated in Victoria in 2007-08, a 37% reduction from the 2000 level.
- Increasing the efficiency of materials use is widely accepted as a necessary step in reducing environmental impact. In contrast, levels of absolute material consumption remain largely unchallenged, yet if increasing the efficiency of material use is not sufficient to reduce environmental pressures, then reducing overall consumption may be necessary.

Objectives

- Reduce environmental disturbance due to natural resource extraction and production processes
- Increase the efficiency of materials used at all stages of production, consumption and waste, including reducing embodied energy and water
- Reduce the environmental pressures of waste disposal

Description

Material is defined as any solid substance¹ used in human activity in Victoria, excluding water and energy, although material use has implications for energy and water. Most familiar as materials are the items used in everyday life such as plastic, glass, aluminium and steel containers, paper and food. However, it also includes clothing, all the items in homes, buildings used for living and working in, and vehicles used for mobility. While monetary flows in the economy are well accounted for, physical flows are not. By understanding and accounting for the physical dimension of material flows that drive the economy, there is greater appreciation of the fundamental dependence of the economy on material flows and their environmental pressures.

Material flows are increasing in Victoria as part of a global trend and they continue to underpin contemporary economic growth. Increasing flows are occurring in nearly all segments of the economic supply chain—from extraction and manufacturing through to consumption and waste. For example, household expenditure on products and services in Victoria is rising faster than the *Consumer Price Index* (CPI), and waste production per capita has almost doubled in the last 10 years. This trend comes despite a structural shift away from the primary and secondary industries and towards service- and knowledge-based industries.

The environmental pressures attributable to materials can occur at every stage of their production, processing and movement through the economy. At each stage in the *supply chain*¹, processes of 'value-adding' occur. Materials are sourced from natural environments and from primary industries. Water and energy are used to manufacture useful products, and waste is produced. The water and energy that are used to make products are then described as embodied 'in' the product. The wastes that are produced at each stage of the supply chain may not be readily absorbed back into the natural environment and some can be potentially hazardous.

From production industries to final disposal, the environmental impacts attributable to materials can be grouped into four broad categories:

- Depletion of natural resources and disturbance or depletion of biodiversity.
- Greenhouse gas emissions, due to energy used in production (embodied energy) and from waste management and disposal.

¹ A chain or progression beginning with raw materials and ending with the sale of the finished product or service. A more complex pattern that incorporates reciprocal service or recycling may be known as a *value network*.

- The use of water in the manufacture of products and provision of services (embodied water), and the impact of this use on environmental flows.
- The production and flow of other potentially hazardous and other (non-greenhouse) waste pollutants from each stage of the value chain.

These issues can be addressed to a certain degree by efficiencies; however, with increasing material efficiency comes the opportunity to use more material – the so-called *rebound effect*² (see Part 2: Driving Forces). Where increasing efficiency fails to decrease overall environmental pressures, reductions in material consumption may be needed.

The degree of environmental impact of materials is determined by both the total amount of materials flows, and by the methods that are used for harvesting, transporting, processing and disposing of materials³.

There are two commonly used methods for conceptualising and quantifying material flows through the economy: *Materials flow analysis*, which measures total (or absolute) amounts of materials; and *Indicators of natural resources intensity*, which measure the intensity (or relative) environmental pressure of different materials or products. Both are essential if the environmental impact of materials is to be assessed, and examples of both are used in this section.

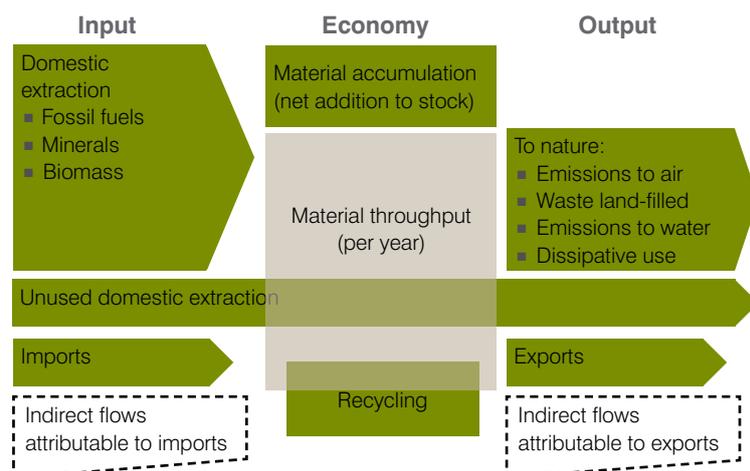
1) Materials flow analysis (MFA)

Until recently, indicators of the amount of material flows and their impacts have been predominantly waste-focused. While studies of waste can provide an insight into some of the environmental issues attributable to materials, a lifecycle approach to materials is a more accurate way to identify total environmental burdens. Significant material flows (and therefore environmental pressures attributable to these flows) are also attributable to the extraction, production and consumption phases of the supply chain. Materials flow analysis (MFA) attempts to quantify these flows⁴. A simplified representation of resource flows through the economy using an MFA is shown in Figure M1.

Materials flow analysis is attracting significant attention from policy makers, particularly in the UK and European Union and in Australia by CSIRO⁵, as part of the attempt to understand and to reduce the environmental impacts brought about by increasing material consumption and waste generation. MFA is a complex and emerging field, one that has not previously been included in State of the Environment reports. As such there is currently inadequate data for a comprehensive MFA for Victoria. Where data is available it is not always disaggregated to the Victorian scale or able to be attributed to a particular economic segment.

Nevertheless, as those indicators that are available to quantify environmentally important material flows at particular segments are explored (Production and Consumption of Materials), each contributes to building an overall picture of the extent to which the economy is dependent upon material flows. The following analysis reports on key material flows within production, consumption and disposal processes as highlighted through application of the MFA.

Figure M1 Economy-wide Materials Flow Analysis (excluding water and air)
Source: Eurostat⁶



Production and Consumption of Materials

2) Indicators of resource intensity

While reporting on volumes of material flow is essential, analysing the environmental impacts of particular products as they move through the production and consumption process is also necessary. Quantifying the resource intensity⁷ of a product is needed to fully understand the resource inputs required; for example, when comparisons between items that provide a similar service are to be made. There are limitations in the use of these measures. While they do provide a picture of the relative impact of certain products, they do not assess the value of alternative uses for a resource and they only provide data that is suitable for comparison measures when a strict methodology is applied (see Box M4).

Natural resource intensity indicators include:

- indicators of embodied energy – either for the entire supply chain, or a single segment of the supply chain per unit of product or service.
- indicators of embodied water – either for the entire supply chain, or a single segment per unit of product or service.
- lifecycle analyses – by definition, for the entire supply chain of a product, which incorporates embodied energy and water, plus any other pressures.

Again, there is not a complete, consistent and accessible Victorian dataset for embodied energy and water. However, Material Use and Environmental Pressures, includes indicators that illustrate the resource intensity of particular products. Case study examples of LCA are also presented.

This chapter uses the methods detailed above to describe Victoria's material flows patterns and the effect that these have on the environment. In addition, it provides an overview of policy responses to the materials challenge, and presents recommendations for adapting to a more materials-efficient future.

Technological advances have created a separation for a large proportion of the world's population from direct involvement in the primary industries—the industries from which all material products originate. This is particularly true for Australia and Victoria where, due to a high degree of urbanisation and the move towards a service-based economy (as measured by employment)⁸, for many people there

is little understanding of how products reach the point at which they are ready for consumption. Despite this distancing, data (see Figure M3) suggest that there is a level of material dependence to the Australian economy which is as high as almost any time in history.

Figure M3 Estimated total domestic material extraction per capita Australia 1980–2002⁹
Source: Sustainable Europe Research Institute

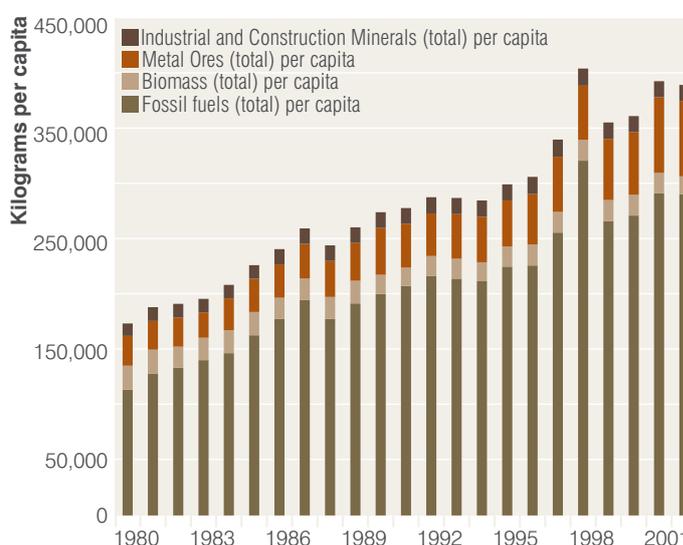
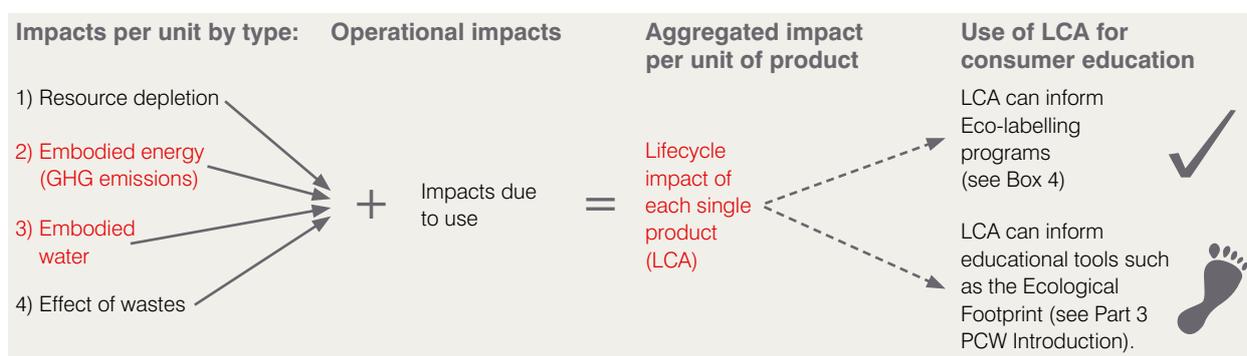


Figure M2 Indicators of natural resource intensity used in this section are embodied energy, embodied water and lifecycle assessment (shown in red)



Estimates of the level of material intensity differ according to methodologies. For example, The World Resources Institute estimates that people in modern economies require between 45,000 (Japan) and 80,000 (USA) kilograms of natural resources per person each year to sustain their lifestyles¹⁰. In comparison, estimates by the CSIRO of *total material requirement* show that partly due to Australia's significant exports, the level of *materialisation* (the trend towards increasing material flows) of the typical Australian has doubled since 1946 to reach approximately 180,000 kg per person in 2001¹¹ – of the same order but less than that shown in Figure M3. These differences are illustrative of the challenge inherent in material flows analyses, especially where data is deficient.

Using the CSIRO methodology, it is estimated that the level of material flows per capita in Australia is twice that of a resident of the United States, and between three and six times that of a resident of Germany, Japan or the Netherlands. For example, Australia exported \$23.8 billion of primary produce and food products in 2005–06, and imported only \$7 billion¹². Material flows are attributed to the country that gains the economic benefitⁱⁱ, and so Australia, with its large primary industry base and as a net materials exporter, is attributed high rates of material flows per capita in the primary industries¹³.

Indicators such as Gross State Product (GSP) are well established and describe the State's economic status and the roles that industry sectors play in this.

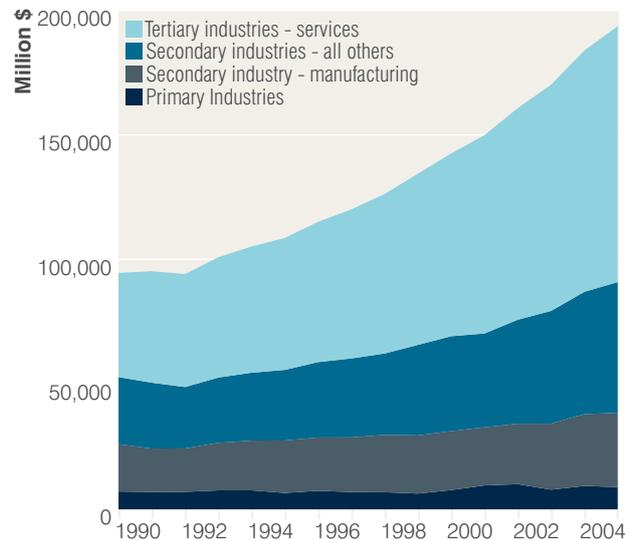
As a result, the economic contribution of sectors to Victoria is well understood. In Victoria, the primary industries accounted for less than 5% of economic activity in 2005 (Figure M4).

Since 1990, Victoria has experienced a relative economic shift away from the materials intensive industries (primary production and manufacturing) as manufacturing has moved to cheaper locations around the world and due to the increasing importance of the service industries¹⁵. Now, approximately 63% of the economy is driven by the less materials-intensive service sector. Despite this, data in the following sections indicate that Victorian consumption and waste

patterns are themselves becoming more material-intensive.

In comparison with economic indices, indicators of the extent of materialisation within industries are less well established. Implementation of comprehensive reporting using the MFA methodology would provide robust measures of material use, resource exploitation and depletion through the economy. What is known is that, generally, primary sectors are associated with higher levels of material flow, while secondary and service sectors, which principally add value to products and provide services, are less materials intensive, and have higher economic value per unit of mass¹⁶.

Figure M4 Total factor income by industry, Victoria
Data source: Australian Bureau of Statistics¹⁴

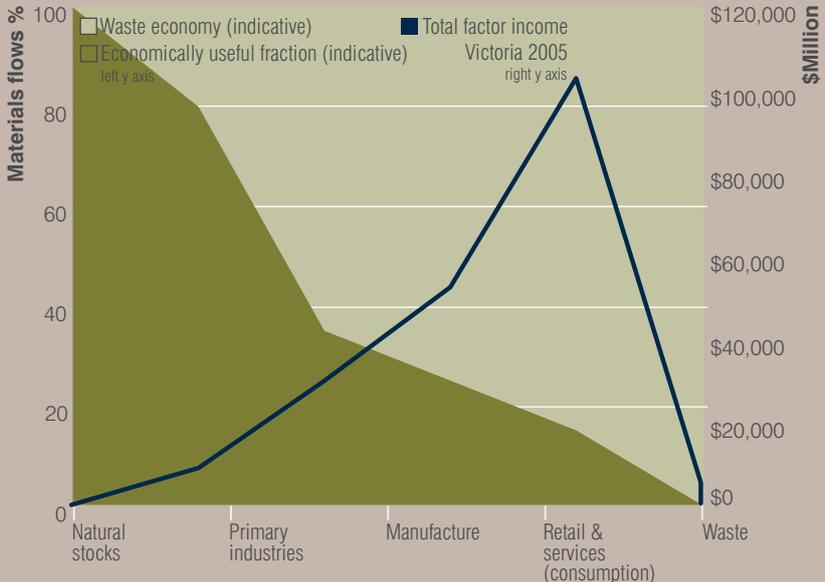


Box M1 Relationship between material flows and economic value

The primary industries are associated with higher levels of material flows than subsequent economic sectors, illustrating the decreasing level of materials intensity that occurs towards the higher value end of the economic supply chain. As materials move through the economic system, value is added.

Part of this process is necessarily enabled through a reduction in the mass of materials, thus implying that within a closed and linear system, the initial input of materials to an economy determines the amount of waste that is produced by the system.

Figure M5 The relationship between material flows and economic value (simplified representation)
Data source: Australian Bureau of Statistics, & adapted from de Bruyn et al.



ii According to standard materials flow analysis methodology, the economic benefit of exports contributes to prosperity and quality of life. For this reason, export material flows are attributed to the country from which they originate.

The following section examines in more detail, where data is available, the extent of material flows within different sectors of the economy: primary industries, 'hidden flows', manufacturing, construction, manufacturing, imports and transport, consumption, and waste and recycling.

Recommendation

M1 Establish a framework for coherent State and Commonwealth materials flow reporting systems using recognised materials flow analysis methodologies.

Primary industries

Victoria's natural environment enables the production of a number of useful material resources. The extraction or harvesting of these resources plays a continuing role in Victoria's economy, affecting patterns of material flow within Victoria and, given these resources' links to global markets, also playing a role in worldwide patterns of material flow¹⁷.

The primary material resources of Victoria include minerals, agricultural products and native plant and animal resources such as timber and fish. The following section provides an overview of material flows attributable to the primary industries. It is not intended to form a comprehensive sustainability analysis of primary industries, but to paint a picture of the extent to which primary industries are integral to the current level of material dependence of the economy. This section also highlights some of the environmental effects of this material dependence. Detail on the effect of this dependence on the state of Victoria's environment is provided in Part 4 of this report.

Minerals

Victorian mineral production has fluctuated in response to global demand and prices, and is estimated to have ranged from around 30 million tonnes in 1970 to almost 40 million tonnes in 2005¹⁸. The production of non-energy minerals is classified into three types: extractive, industrial and metallic. Victorian production of key extractive minerals is shown in Figure M6.

In addition, hard rock production was estimated at 28 million tonnes and heavy mineral sand production at around 600,000 tonnes in 2005–06. Gold rock^{iv} extraction is estimated at 4.8 million tonnes in 2007¹⁹. In 2005–06, Victorian extractive industries were estimated to be worth over \$500 million annually and represent the most significant component of the mineral resources sector.

The production of industrial minerals such as gypsum, kaolin and feldspar also constitutes an important contribution to total mineral production, with an output of 635,000 tonnes in 2005-06. In terms of metallic minerals other than gold, Victorian copper and zinc production has been sporadic, occurring mainly during the mid-1990s²⁰.

The environmental impacts attributable to minerals at the first stage of their utilisation (at mine sites) is a relatively small component of their total impact; although, depending upon how they are managed, the movement of overburden and interseam rock can have environmental impacts (see 'Hidden flows', below). Energy use by the mining industry constitutes a component of the total energy embodied into the products that are produced. Likewise, water use by Victorian mining industries forms a

relatively small proportion of overall water demand (around 40,000ML in 2004–05)²¹ (see Part 3.2: Water Resources), yet constitutes a component of the total water embodied into products of the industry sector.

Apart from hidden flows and embodied water and energy, there are a number of other environmental pressures associated with the extractive stage of minerals production. They can include clearing of vegetation at mine sites, the spread of pest plants and animals and impacts on hydrological systems due to use of water in mining and from pollution. These are covered in Part 4.2; Land and Biodiversity.

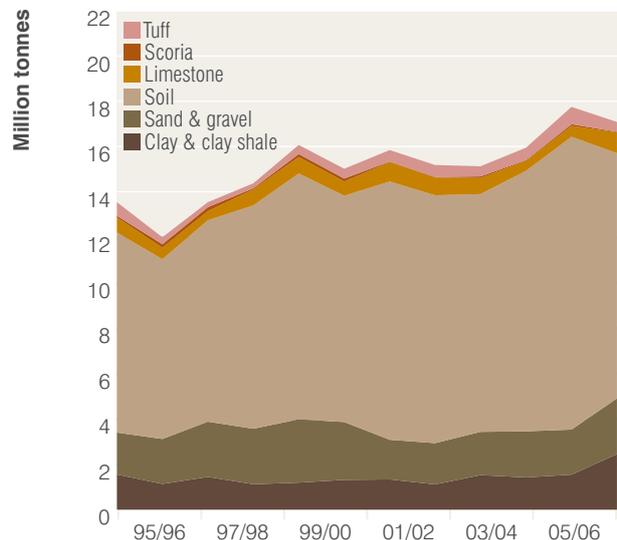
Agriculture

Victoria's principal agricultural products are cereal grains, other crops including horticultural produce, wool, milk and meat products. Production of each of the first four of these has been steadily increasing since the late 1800s, except for wool production, which, due to drought, has exhibited a decline since 1990 that now appears to be stabilising.

Almost 4.5 million tonnes of cereal grains were produced in 2004–05. In 2003–04, Victoria's contribution was estimated at 0.5% of worldwide grain production²². Almost 1.8 million tonnes of horticultural produce was produced in 2004–05, a slight increase from the previous year²³.

Of total livestock production in 2004-05, milk constituted the greatest single component, at 6,777 million litres. Data on meat production is not available prior to 1973 but shows a slight increase over the last 34 years²⁴. Beef and chicken were important components of total annual production, at 363,000 and 220,000 tonnes respectively.

Figure M6 Material flows associated with extractive mineral production in Victoriaⁱⁱⁱ
Data source: Australian Bureau of Statistics¹⁴



iii From the early 1990s gravel was increasingly grouped with sand.
iv Gold rock value is indicative for the tonnage of rock moved to achieve the recorded gold production for that year.

The environmental impacts from energy use in the agricultural sector (see Part 3.1: Energy) are a relatively small component of the total environmental impact of food production. By contrast, the methane emitted is a significant pressure on the climate (see Part 4.1: Atmosphere), while water use by irrigated agriculture (75% of water used in Victoria) is also significant (see Part 3.2: Water Resources). This constitutes the greatest proportion of total water embodied into food and other agricultural products. Of particular significance is milk and dairy, due both to its high levels of production and its relatively high level of water intensity (See Embodied water).

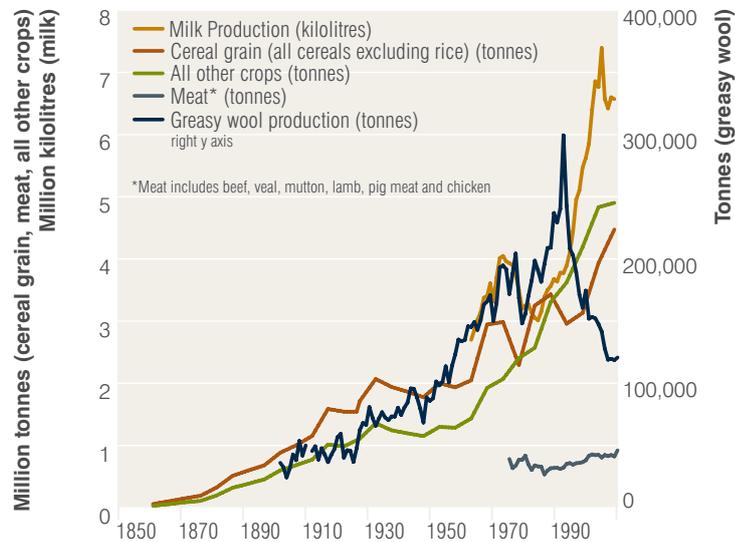
The other environmental pressures associated with the production of agricultural products are covered in Part 4 of this report and their combined impacts can be represented by the *Ecological Footprint*. These pressures include clearing of native vegetation, the spread of pest plants and animals, greenhouse emissions from land use change, the management of topsoil, erosion and sedimentation, salinity and waterway pollution.

Fisheries

Fisheries production in Victoria consists of recreational wild harvest, commercial wild harvest (from both Victorian and Commonwealth fisheries) and aquaculture production.

Aquaculture is playing an increasingly important role, although fisheries production still relies predominantly on wild harvest. Recent reported production levels are historically low when compared to production figures from years where fisheries were managed to provide for maximum yield. Biodiversity depletion is a significant outcome if fisheries are poorly managed. In the past, fisheries were managed to provide for *maximum yield*²⁷ which led to a decline in stocks of many fisheries. The objectives for the management of Victoria's wild capture fisheries have changed in recent years to ensure fisheries resources are harvested to provide for *maximum sustainable yields*. This has resulted in a general decline in fisheries production in Victoria over the last three decades, associated predominantly with a decrease in fishing effort due to these limits. Fisheries are still considered to be *fully exploited*, although recent management plans do limit catch in an attempt to restore populations of some species.

Figure M7 Estimated Victorian agricultural production by type 1850 – 2004–05*
Data sources: CSIRO, Australian Bureau of Statistics²⁵



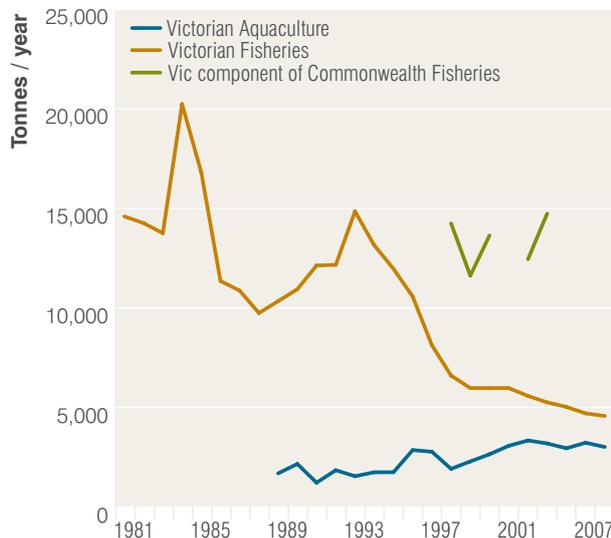
A modelled example of the effect of different management regimes on a fishery is shown in Material Use and Environmental Pressures, while the state of marine biodiversity is covered in Part 4.4: Coasts, Estuaries and the Sea.

The other environmental pressures associated with fisheries are similar to those associated with the other primary industries. The requirement for water and energy to process, package and transport the products of fisheries means that the volume of materials involved in

the industry has important environmental implications. While important, the environmental impacts attributable to energy use in the fisheries sector (see Part 3.1: Energy) are a relatively small component of the total environmental impact of food production from fisheries.

A much greater component of the total embodied energy in consumable fisheries' products is incurred at the processing, packaging and transporting stages of the supply chain (See Embodied energy).

Figure M8 Figure M8: Victorian fisheries production by industry 1981–2007^{vi}
Data sources: CSIRO, Department of primary industries, Australian Bureau of Agricultural and Resource Economics²⁶



v *Meat includes beef, veal, mutton, lamb, pig meat and chicken.

vi Data for Commonwealth fisheries with Victorian coverage is not available for certain fisheries for certain years.

Forestry

Timber and other forest products in Victoria come from both plantation and native forests. Comprehensive and systematic time series data for timber production in Victoria is not available. However, it is possible to conclude that production from native forests has progressively reduced over the last 50 years²⁸, while plantations are playing an increasing role in Victorian timber production.

Softwood and hardwood plantations occupying less than 2% of the area of Victoria³⁰ are estimated to account for well over 300,000 tonnes of annual production³¹ - over half of Victoria's total timber production; however, exact figures are unavailable.

Unsustainably harvesting timber from native forests can lead to environmental disturbance and can affect hydrological patterns. Effective monitoring is critically important to sustainable forest management. Currently, Victorian forestry is subject to a system of regulation and governance underpinned by principles of ecologically sustainable forest management³². The condition of biophysical factors including that of native forests is covered in Part 4.2: Land and Biodiversity.

The use of forest and plantation produce also has implications for the environmental issues of embodied water and embodied energy and for waste generated at the end of products' life. For example, the increase in use of plantations to supply wood and wood products may have implications for

environmental flows (see Part 3.2: Water Resources), although more research is needed. Likewise, within a lifecycle context, the energy used in forestry is one of the environmental pressures associated with the industry (see Part 3.1: Energy) and contributes to the total energy embodied into forest products.

Primary industries - Summary

With the exception of fisheries, material production in each of Victoria's primary industries is increasing. Depending upon how they are managed, production in primary industries can lead to environmental disturbance and, in some cases, depletion of natural resource stocks. Also of environmental significance is the energy and water that is invested into primary products during this stage of the supply chain. As demand for and consumption of products sourced from natural resources continues to increase, these pressures are also expected to increase.

Recommendation

M2 The Victorian Government analyse the feasibility of undertaking consistent and replicable materials flow reporting for the primary industries to complement the extensive economic reporting already in place (see also M1, M3 and M4).

Hidden flows

According to MFA methodology, hidden flows are the materials removed during processes of domestic extraction or harvest that are not physically included in the production of goods³³. The OECD defines hidden flows as the *displacement of environmental assets without absorption into the economic sphere*³⁴. Depending on how they are managed, hidden flows can cause environmental pressures³⁵.

Preliminary indicators of hidden flows take the form of *factors* that are dependent upon system characteristics intrinsic to the industry under consideration. For example, the hidden flow factor of soil loss during crop production in Australia (i.e. above that which is attributable to normal weathering processes on non-agricultural land) is estimated at 0.64 tonnes per hectare of farming land per year³⁶. As a comparison, it is estimated that the typical hidden flow factor for gold mined in Australia is 3,499 tonnes of overburden moved and ore processed for every kilogram of gold produced³⁷. When these factors are used in conjunction with total volumes of material produced from primary industries, the scale of total hidden flows can be explored.

Total Victorian hidden flows are estimated to have increased by 300% since 1946, reaching almost 300 million tonnes in 2006 (Figure M10).

The impacts of hidden flows may be due to the direct impact of the flow (for example, clearing of vegetation, altering of landform and hydrology due to mining overburden) and/or indirectly (for example, as a result of energy used by vehicles to remove vegetation or move overburden).

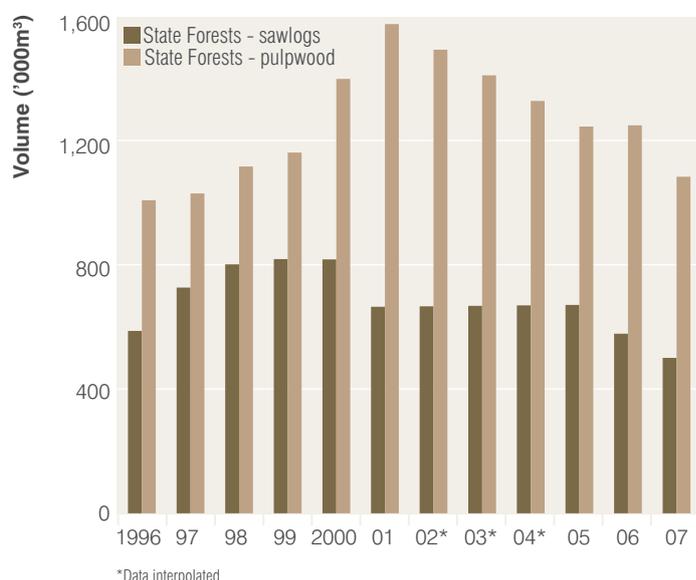
There is an increasing awareness of 'hidden' flows and their environmental impacts. Primary industries, particularly mining, are increasingly internalising the costs of these impacts into their budgets. Factoring the cost of environmental management of hidden flows into operating costs effectively changes their definition and creates an economic imperative to reduce such flows, which can also increase the materials efficiency of production and manufacturing.

Recommendation

M3 The Victorian Government encourage primary industries to use materials flow reporting systems for all major 'hidden' flows, and investigate the economic and environmental benefit of internalising their full environmental cost into industry operating costs (see also M1, M2 and M4).

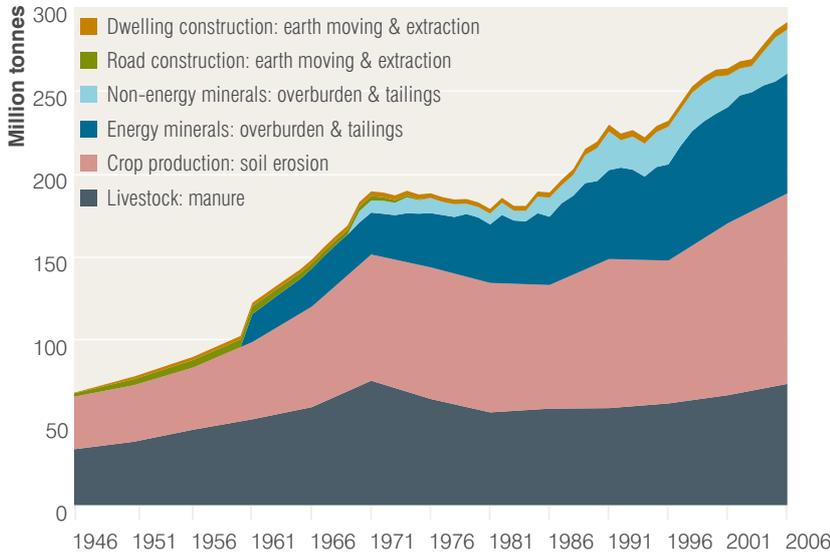
Figure M9 Estimated annual Victorian State sawlog and pulpwood harvest 1996-2007^{vii}

Data sources: CSIRO, Department of primary industries, Australian Bureau of Agricultural and Resource Economics²⁶



vii Data for years 2002, 2003 and 2004 is interpolated.

Figure M10 Estimated volume of hidden flows by six major activities in Victoria^{38,viii}
Data sources: CSIRO



Construction, manufacturing, imports and transport

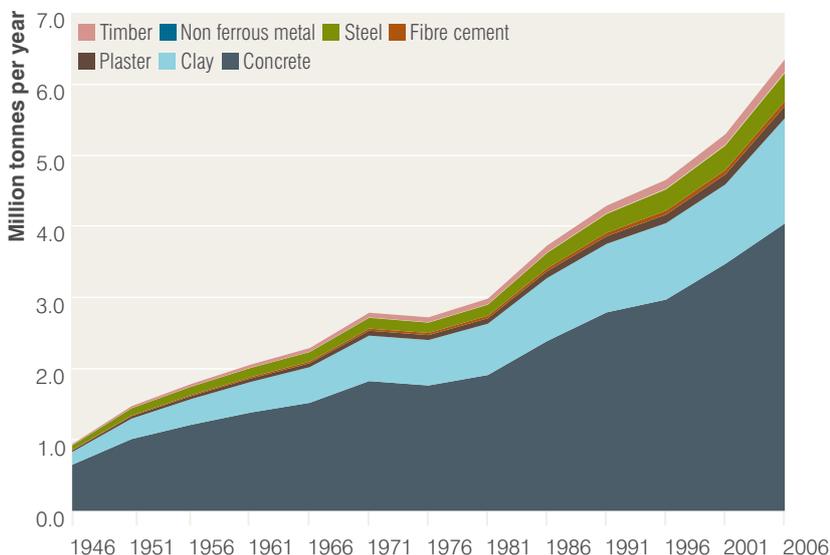
Construction, manufacturing and transport are secondary industries that add value to materials. Comprehensive data on material flows in these industries is not available; however, the following examples are included in order to illustrate some trends in these sectors.

Construction and manufacturing

Material flows attributable to construction in Victoria have increased almost 600% during the post-war period (see Figure M11)³⁹, while the contribution of construction to the economy has increased from 8% in 1993 to 15% in 2008⁴⁰.

The manufacture of construction materials uses significant amounts of energy (See 3.1: Energy), which is then embodied into buildings (see Embodied energy, below). The increase in material flows in construction, shown above, has important implications for environmental pressures associated with emissions from energy use. There is potential for the Australian Procurement and Construction Council (APCC) to play a greater role in providing industry leadership for best practice assessment and use of materials for sustainability.

Figure M11 Materials flow in construction in Victoria
Data sources: CSIRO⁴¹



^{viii} Data for energy minerals and non-energy minerals are only available from 1961 and 1970. These estimates are approximate and should only be considered as order of magnitude illustrations.

Box M2 E-crete – A geopolymers concrete made in Melbourne - leading the world

Concrete is the second-most widely used material on earth, with 20 billion tonnes produced annually⁴². It is estimated that for every person on earth, three tonnes of concrete is produced annually⁴³. Figures vary, but it is estimated that the manufacture of cement, the reactive ingredient in concrete, is responsible for 5-8% of the world's CO₂ emissions⁴⁴. Traditional concrete is made by heating calcium carbonate until it breaks down into calcium oxide, the essential ingredient of cement, with carbon dioxide produced as a by-product of this process.

E-crete is completely different. Developed by Zeobond Pty Ltd, a world-leading company in geopolymers technology located in Campbellfield, Victoria, E-crete is based on aluminium and silicon, which are ingredients that do not need to be heated in a kiln, a greenhouse intensive process. Further, the chemical reactions of the process do not generate carbon dioxide. The aluminosilicate materials are combined with fly ash and smelting slag, by-products of the combustion of coal and iron ore smelting respectively. Finally, sand, water and a small amount of alkaline solution is added to make the final product, known as a geopolymer concrete.

Independent audits have found that manufacturing E-crete releases less 40% of the CO₂ of traditional concrete manufacturing⁴⁵. E-crete currently costs about 20% more than traditional concrete. However, the market is currently in its infancy and it is anticipated that costs will reduce once the product goes into full production and economies of scale improve. Zeobond currently produces E-crete from its Melbourne-based facility and is in negotiations with companies in the US, China and India.

In contrast to construction, the economic role of manufacturing in Victoria has seen a comparative decline over the last 15 years⁴⁶. This is a result of increasing globalisation⁴⁷ and the unbundling of the supply chain⁴⁸ that has allowed Australians to benefit from cheap manufacturing offshore, particularly in China and India. Within Victoria, the manufacturing industries of greatest economic importance are machinery and equipment, cars, food and beverages, dairy products, pharmaceuticals and metals⁴⁹. In comparison with economic data, materials flow data for manufacturing is generally poor; however, Victorian paper manufacturing is one example that can be used to illustrate a trend in material flows in manufacturing (see Figure M12).

Despite the expectations by some of a move towards a reduction in paper use (the *paperless office*)⁵¹, paper production in Victoria has been growing steadily since 1970. The trend towards the increasing role of paper recycling is encouraging but the gains are offset by the trend in overall production and consumption.

Where commodity use is rising, there are limited ways to limit overall environmental impact. One way is to ban the manufacture of products that incur a disproportional environmental pressure. Another way in which the impact of a single product can be reduced is to increase the materials efficiency of manufacturing processes. On a per unit (product) basis, this is referred to as *dematerialisation*⁵². Increasing the materials efficiency of manufacturing, for example via dematerialisation, is

one of the mechanisms that increases the economic efficiency of businesses, enabling them to grow. An example of dematerialisation is the reduction in the amount of metal required to make food containers (see Figure M13).

While dematerialisation is commonplace in industry, it is in itself unlikely to lead automatically to a reduction in material flows within manufacturing. This is because in the absence of demand management, increasing material efficiency brings with it the opportunity to use more material – the so called *rebound effect* (see Part 2: Driving Forces)⁵⁵.

The level of material flow through the manufacturing industries is an important factor contributing to the environmental impacts attributable to that sector. Energy use by manufacturing is second only to that used in transport, and is increasing (see 3.1: Energy), while Part 3.2: Water Resources shows that manufacturing is also dependent upon water supply (see also Embodied water).

Imports

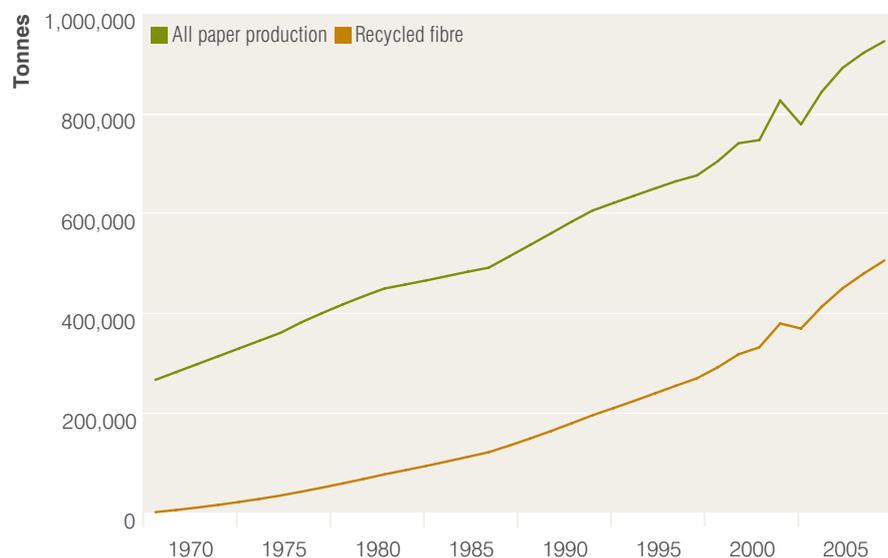
Despite the declining economic importance of local manufacturing, Victorians are demanding an increasing quantity of manufactured goods. As participants in the global economy this demand is met by imports. Materials flow data for imports is not available, but some trends can be inferred using economic data.

Between 1988 and 2007 the value (as opposed to material mass) of total merchandise imports to Australia increased by 425%. This includes items

that are used in primary and secondary industries that can contribute to improving the efficiency of these industries, and also luxury items of high value. However, a large proportion of this value is attributable to a wide range of consumables such as cars, paper, televisions, prams, textiles, clothing, and seafood products. When factored against population and a cost of living index such as CPI (which increased 13% and 80% respectively over the same period⁵⁶), the increasing value of imports is indicative of an increasing level of imported material⁵⁷.

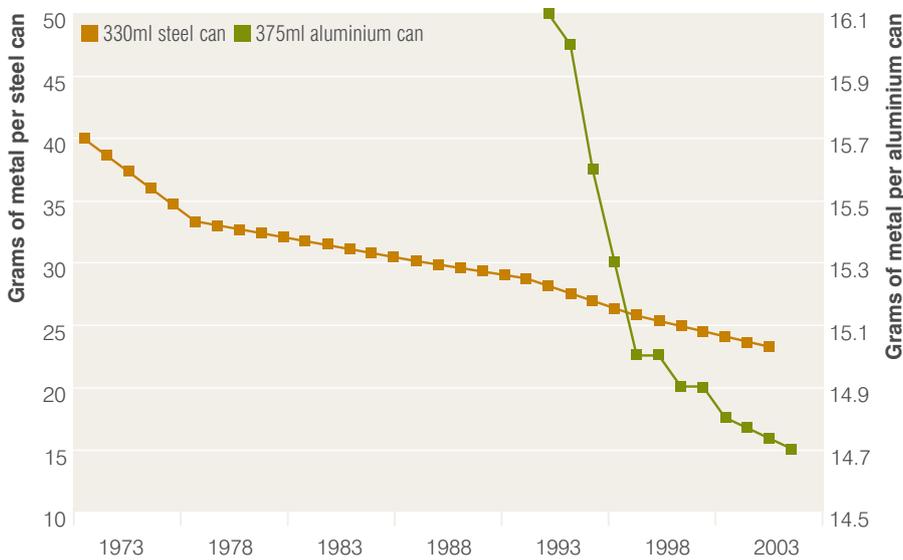
One of the implications of this trend is that while the environmental impacts of manufacturing processes are not attributed to imported products in the place of consumption, there are nevertheless impacts incurred, including waste generation, at their place of origin^{ix}. For many manufacturing processes, globalisation has simply relocated environmental impacts associated with manufacturing processes (for example, localised SO_x and NO_x air pollution) out of Victoria and Australia, in some cases to countries with lower environmental standards. Where these impacts are global, such as climate change arising from greenhouse gas emissions, Victoria is subject to them irrespective of where manufacturing takes place.

Figure M12 Paper manufacturing in Victoria
Data sources: CSIRO⁵⁰



^{ix} Under certain circumstances there may be a net environmental benefit to overseas production. For example rice grown in countries where water is more readily available than it is in Victoria places a comparatively smaller pressure on water supply.

Figure M13 Dematerialisation in aluminium and steel cans
Data sources: The Aluminium Can Group, The Association of European Producers of Steel for Packaging^{53,54}



Trade and transport

Transport is not usually a dominant source of impact attributable to materials, although the rise in trade and transport as a whole is a significant pressure because of the attributed emissions (See Part 3.1: Energy). Material flows attributable to transport are not available, although an analysis of the trend in imports in terms of tonne-kilometres of goods transported provides a good proxy indicator. As a global participant, Victoria's exports also contribute to Victoria's prosperity and, albeit in a relatively small way, to the level of material intensity of the global economy. Figure M14 shows an increase for both Victorian shipping imports and exports between 1985 and 2005⁵⁸.

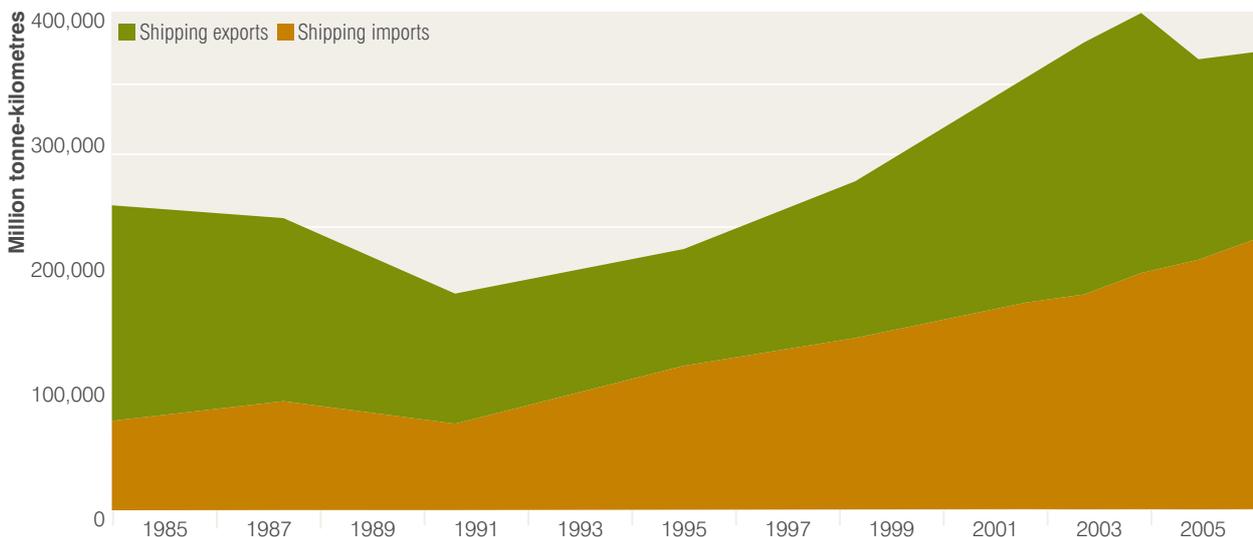
This increasing, statewide trend is repeated at the scale of local transport networks, with implications for the amount of material required to maintain and expand regional road, rail and shipping infrastructure⁶⁰. The current channel-deepening proposal (see Part 4.4: Coast, Estuaries and the Sea and Part 5: Living Well Within Our Environment) is in response to a projected fivefold increase in freight by 2035⁶¹ and has the potential to induce further demand for imported products, thus increasing materials flows in Victoria.

Transport indicators illustrate growth in the mobility of goods. Hence, while they do

provide some indication of the mass of materials moving through the economy, they do not represent absolute quantities of materials. This is because a tonne of material will travel via a number of modes as it moves through the economy towards its site of final consumption and disposal.

What the rising freight task more clearly indicates is the importance society places on the mobility of material. The energy used in the freight and transport sector translates directly into the energy intensity of products that are used every day. Embodied energy is described further in Material Use and Environmental Pressures.

Figure M14 Trend in total international shipping freight task, by tonne-kilometres travelled
Victoria, 1985–2005
Data sources: Apelbaum Consulting Group⁵⁹



Construction, manufacturing, imports and transport – Summary

There are significant gaps in materials flow data for these segments of the economy. Nevertheless, there is strong evidence to suggest that material flows in secondary industries are increasing. While dematerialisation can play a role in increasing the efficiency of materials use, alone it is unlikely to bring about a reduction in material flows.

The activities associated with construction, manufacturing and transport create pressures on the environment. Of particular significance is energy use. With increasing materials flows come increasing pressures attributable to the energy that is invested into products. Waste, including potentially hazardous wastes that are produced during manufacturing, can also cause environmental pressures (see Material Use and Environmental Pressures).

Recommendations

M4 The Victorian Government establish comprehensive materials flow reporting systems for manufacturing, and for imports and exports, in order to aid decision-making and regulatory approaches for reducing the environmental pressures of materials (see also M1, M2 and M3).

M5 The Victorian Government encourage the wider use of tools such as ISO standardised methodologies for measuring the environmental pressure of materials in manufacturing and construction (See also M9, M11 and M19).

M6 The Victorian Government provide further incentives via the *Environment Protection Act 1970* to manufacturing industries to add value to all products, while increasing materials efficiency.

Over the past 90 years, population has increased an average 1.7% per year. In the same period, the number of households in Australia has increased by an average 2.4% per year⁶³. In combination with a decline in fertility levels, these trends have led to decreasing average household size (that is, the average number of people living in a house). In line with increasing consumption there has been a trend towards larger houses; for example, a 36% increase in floor area per house between 1985 and 2002 (see Figure M15).

More and larger houses mean a greater volume of building material use, which, depending upon the types of material used, has environmental implications. The energy and water used in the operation of homes is important (See Part 3.1: Energy and Part 3.2: Water Resources), but of particular relevance for materials flow analyses is the amount of embodied energy and water in construction materials.

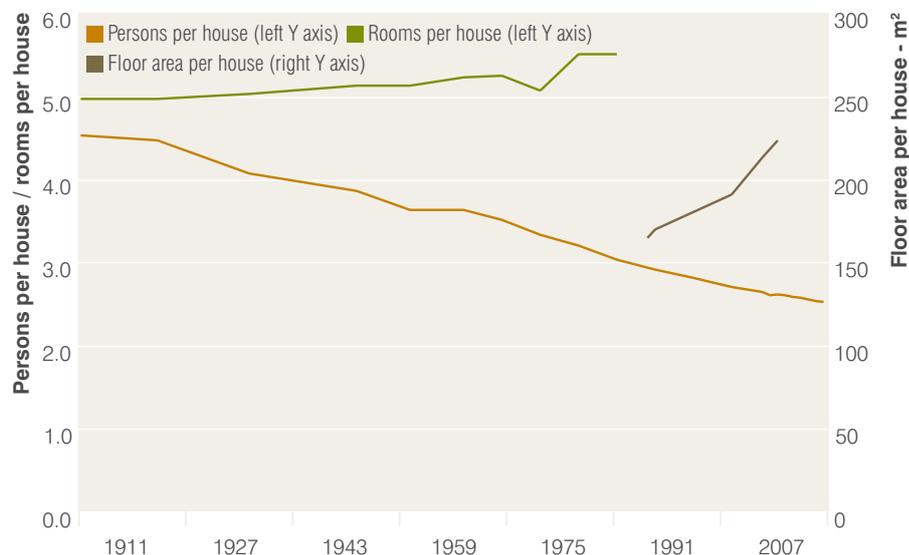
Consumption of materials

Consumer demand is driving a steady increase in material flows across all sectors of the economy. In turn, this is driving Victoria's strong position in the global economy, as illustrated by its growing GSP, and has led to a steady rise, in real terms, of personal and household incomes (see Part 2: Driving Forces). One result of increasing wealth is the increase in spending on goods and services⁶² relative to the CPI, a trend which is reflected in the consumption rates of a variety of commodities.

Increasing incomes and larger houses also provide space and incentive for more household items (furnishings, appliances, etc.), and it is likely that increasing incomes have also meant a greater turnover rate of household products. More products require more material, water and energy resources to manufacture and transport, as well as implying an increase in waste at end of life. Figure M16 shows annual purchases of selected whitegoods in Victoria from 1993 to 2005.

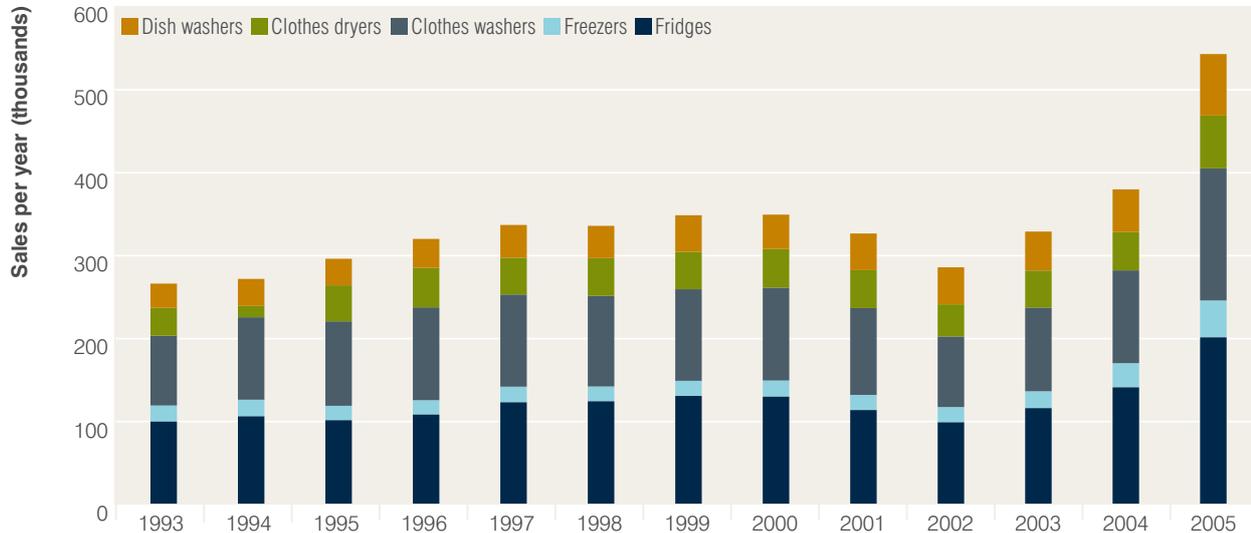
Figure M15 Change in average house size (rooms and floor area per house) compared with average household size (persons per house) Australia 1911–2003*

Data sources: Adapted from Australian Bureau of Statistics⁶⁴



* Rooms per house is not available after 1982; floor area not available prior to 1985.

Figure M16 Annual sales of selected whitegoods in Victoria 1993–2005
Data sources: Energy Efficient Strategies⁶⁵



The trend towards increasing consumption of materials is also exhibited in an analysis of the number of motor vehicles registered. The total number of vehicles increased from 3.1 to 3.8 million between 1998 and 2007⁶⁶ – at a rate faster than that of population growth⁶⁷. This represents a significant increase in the total number of vehicles in operation. Increasing vehicular mobility brings significant social benefit, yet also increasing environmental pressures (See Part 3.1: Energy).

As for all other stages in the economic value chain, increasing the materials efficiency of the consumption phase is essential if environmental pressures are to be reduced. In addition, given that current consumption levels, in absolute terms, are a force that drives environmental pressures (see Part 2: Driving Forces), there may be environmental benefit in reducing material consumption. This issue is further dealt with in Part 5: Living Well Within Our Environment.

Recommendation

M7 The Victorian Government consider the establishment of pilot programs targeted to reduce material consumption for key, high impact consumables via demand management programs such as those that have already been initiated for energy and water.

Material outputs; waste and recycling

Indicators of material outputs complete the picture of the extent and intensity of material flow in Victoria. Waste is usually understood as the valueless material outputs of consumption. In contrast, use of the material flows analysis terminology material outputs, indicates the potential of ‘wastes’ to be valuable as inputs to further economic processes. According to the MFA methodology, material outputs can be classified according to the way in which they are managed; for example, by recycling, or being returned to the natural environment⁶⁸.

Actively managed wastes refers to all methods of material output management that are controlled or managed. At the broadest level this includes recycling and landfill, sewerage (covered in Part 3.2: Water Resources) and re-use and refurbishment programs that are designed to increase materials flow efficiency.

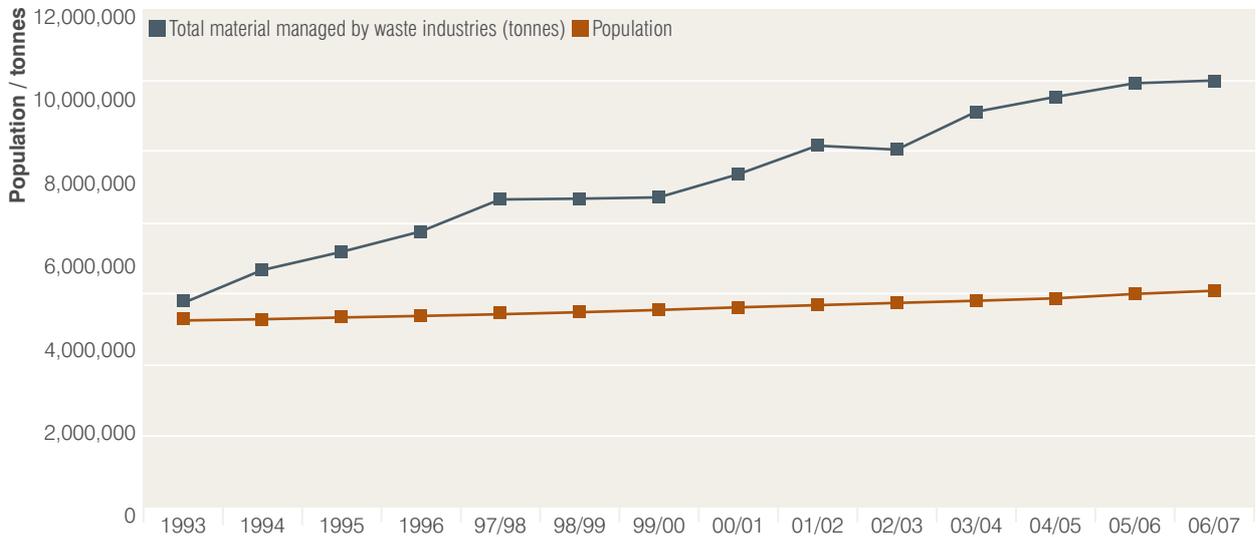
Unmanaged outputs of material from the economy include litter and dissipative outputs, examples of which are particulate material dissipation from the wearing of car tyres, spreading of fertilisers for agriculture and the use of aerosols. Total unmanaged outputs are difficult to quantify, yet can be precursors to emissions to water and air. Some major dissipative emissions are covered in the Energy and Atmosphere sections. In some cases the attribution of dissipative outputs to particular products that lead to pollution is done using lifecycle assessment (see Material Use and Environmental Pressures).

Since 1993 the amount of material managed via the active processes of recycling and landfill shows relative decoupling from GSP⁶⁹ (see Part 2: Driving Forces). Despite this, total material output continues to increase⁷⁰. On a per capita basis, the level of material intensity of Victoria at the waste and recycling stage of the economy has doubled in 13 years. At two tonnes per person in 2007, each Victorian is now, on average, responsible for twice as much material output as in 1993.

The main reason for the increase in total material output is the increase in total material consumption⁷². This is likely to be driven primarily by economic factors (including higher incomes), with demographic factors playing a minor role (see Part 2: Driving Forces).

Figure M18 shows that in 2006–07, the waste recovery diversion rate (recycling) in Victoria was 62%, a significant increase since the 1993 rate of 26%⁷³, and a result that is mirrored by national data⁷⁴. When compared to international examples, however, there is room for improvement. For example, it is estimated that Belgium recycles 94% of all steel cans used, while the rate for Victoria is only about 56%⁷⁵.

Figure M17 Amount of waste managed (recycling & land-fill) and population 1993–2006/07
Data sources: Sustainability Victoria⁷¹



This trend towards a higher proportion of material output that is actively managed by recycling and other recovery processes is encouraging, and would improve with increases to the landfill levy. Nevertheless, the benefits of the improving diversion rate are outweighed by the increase in total waste generation over the same period, particularly when considered against population change.

Active material output management practices, both recycling and landfill, require energy and water, with different amounts required depending upon the method used. However, when the resources used by recycling industries are considered in the context of a whole-of-lifecycle assessment of products, the

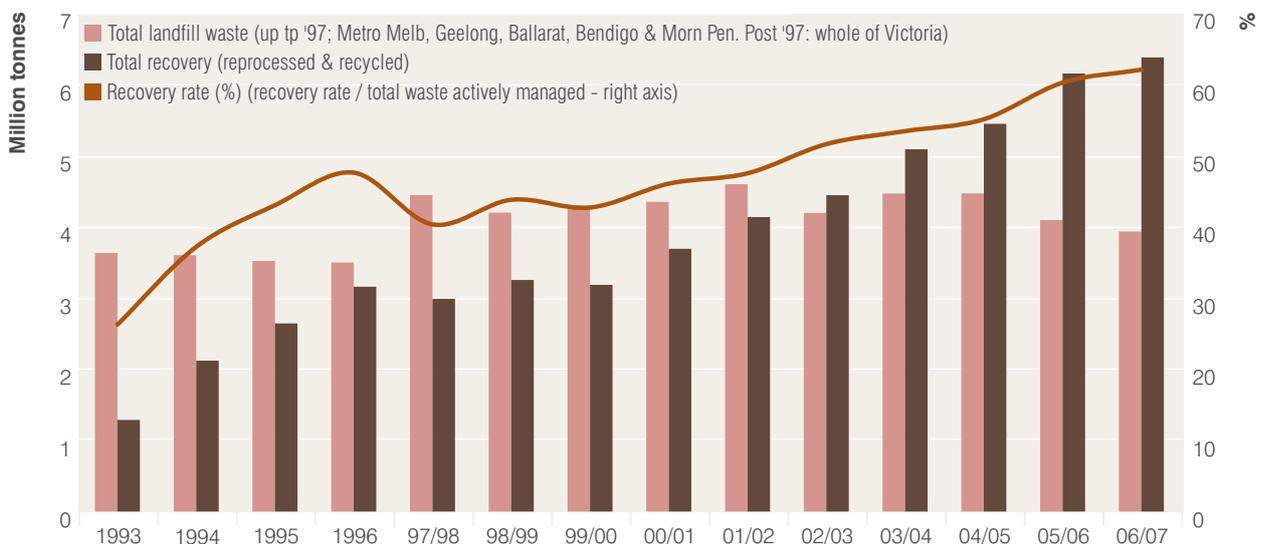
(recycling) of wastes is able to preserve a proportion of the resources (particularly energy) invested into products, enabling lifecycle benefits within other segments of the materials value chain. The environmental implications of different waste management practices are further addressed in Environmental pressures of waste.

Recommendation

M8 The Victorian Government set a stretch target of zero waste by 2020 and implement annual increases to the landfill levy to:

- a) provide disincentives to the use of this as a waste management option.
- b) raise funds to provide incentives to industry for R&D for increased materials efficiency.

Figure M18 Total amount of managed material output (recycling and landfill) and diversion rate 1993–2006/07
Data source: Sustainability Victoria⁷⁶



Production and consumption of materials - Summary

Available data indicates that absolute material flows are increasing in nearly all sectors of the Victorian economy. In many cases, there is also an increase in material flows per capita. While certain industry segments, particularly local manufacturing, exhibit a decline in economic importance, this decline is offset by the increased reliance on imports—evidence of the Victorian economy's interdependence with the global economy. While most of the environmental impacts attributable to imported goods are incurred offshore, it is local consumption of such goods that is the key driver of these impacts. Similarly, while a large proportion of Victorian primary produce is exported, it contributes to Victorians' prosperity⁷⁷, and it is important to ensure that these industries are sustainable.

The growth in absolute mass of material flows does not necessitate a directly proportional increase in environmental pressure, yet the preceding indicators show strong correlations. In addition, there are environmental limits to the availability of many material resources as well as in the ability of the environment to absorb waste. Therefore, with greater material flows comes a greater risk of environmental pressure. While it is essential that the extent of environmental pressures attributable to material flows is assessed by the scale of material flow (see Production and Consumption of Materials) wherever possible, the impact per unit of service also needs to be addressed. The next section explores some of the environmental pressures, absolute and relative, attributable to materials flows.

Material Use and Environmental Pressures

The environmental pressures attributable to material flows occur at every stage of products' lifecycle. From primary production to final disposal, these pressures can be grouped into four broad categories:

- Depletion of natural resources and disturbance or depletion of biodiversity.
- Greenhouse gas emissions, due to energy used in steps along the supply chain (embodied energy) and in the decomposition of products.
- The use of water in the manufacture of products and provision of services (embodied water), and the impact of this use on environmental flows.
- The production of waste and pollutants to air, land and water (excluding greenhouse emissions associated with energy) from each stage of the supply chain.

This section explores these pressures through the use of scenario modelling, indicators of the resource intensity of material products, and indicators of the extent of the environmental pressure attributable to waste.

Finally, case studies of lifecycle assessment (LCA) are used to provide examples of the extent of each of the above pressures as they are attributable to a single product. The use of LCA enables all environmental impacts attributable to a product (listed above) to be aggregated and presented in a form such that comparisons can be made between products. LCA may then be used to inform product labelling programs that enable consumers to choose between products according to environmental criteria.

Environmental disturbance and resource depletion

All material products that are used in everyday life are originally sourced from environmental stocks, some of which are renewable (forests and fisheries) and some of which are not renewed within human time scales (soil, fossil fuels and minerals). The rate at which resources are extracted from the environment can affect the structure and function of ecological systems. The following two examples illustrate this using scenario modelling.

Case study - Fisheries and marine stocks

Historically, the effect of increasing demand for seafood has led to a decline in populations within some fisheries. For example, previous fishing regimes reduced the stocks of the Victorian Rock Lobster. The Department of Primary Industries regulates the fishery by enforcing a total allowable commercial catch (TACC) limit. Using scenario modelling, the DPI can estimate the recovery rate of this fishery under different TACC scenarios. This modelling shows that with increasing TACC limits, the likelihood of the fishery recovering to its 1951 level decreases. For example, at a catch limit of 460 tonnes per year, there appears to be no likelihood that the fishery will recover to even the target reference point of 40% of the 1951 level⁷⁸.

Figure M19 shows the effect of three different TACC limits on **biomass** (stocks) in this fishery.

Prior to April 2007, the TACC was 450 tonnes per year. DPI has used this information to set a TACC limit for the period April 2007 – April 2008 at 380 tonnes. This is proposed to be reduced to 320 tonnes for the period April 2008 – April 2009⁷⁹. This level aims to achieve a balance between commercial interest and regeneration (to 40% of the 1951 biomass level by 2017) of this important resource. For more information on fisheries see Part 4.4: Coasts, Estuaries and the Sea.

Hypothetical modelled scenario - Agriculture and land degradation

The CSIRO has used the Australian Stocks and Flows Frameworks (ASFF)⁸⁰ to model the effects of different primary industry management scenarios on natural resources⁸¹. A hypothetical future scenario based on modelled historic data is presented here to illustrate how different land management practices can have an effect on the condition of soil, a natural resource.

For agriculture, two scenarios are presented⁸²:

Scenario 1: Extent of land under crop and grazing activity is fixed at 2001 levels.

Scenario 2: 'Post-agriculture' which is described as one which:

Recognises and capitalises on the diverse values people see in our landscapes, and seeks to take regional Australia beyond its dependence on 'European-style' agriculture. Under this scenario, nationally the area of rain-fed crops and sown

pastures halves with 19 million hectares revegetated for forestry and conservation, the area of irrigated land falls (by 40%), providing 8,700 GL (of water) for additional environmental flows. Farming systems on the remaining cropland undergo a gradual revolution to better suit Australia's poor soils and variable climate, leading to substantial decreases in land degradation and steady increases in yields⁸³.

For each scenario, two indicators are graphed below.

- 1 The total area of land under agricultural management, and
- 2 The area of land that is subject to degradation, as defined by a 20% reduction in agricultural production yield.

Figure M20 shows that if agricultural land is fixed at the 2001 extent (Scenario 1), then the amount of land that is degraded continues to increase. In contrast, a reduction in agricultural area, and associated land rehabilitation (Scenario 2), results in the area of land that is degraded (20% yield loss) reaching zero by 2040.

It is also important to note that, under Scenario 2,

Despite substantial reductions in the area of most crops, production continues to exceed domestic demand by a factor of two or more for all commodities. The scenario sees a considerable contribution to regional economies coming from new non-agricultural industries that are attracted by increasing amenity values and facilitated by communications technology. Success of this scenario depends on the development of new agricultural systems that are better suited to Australia's environment, improving the net income from managed and native ecosystems through value adding and development of markets for new products and services, and attracting non-rural businesses to regional Australia⁸⁴.

Scenario 2 therefore describes an example of ecologically sustainable development, where agricultural production rates are able to be maintained at a level beyond that required for domestic demand, such that an export industry is maintained, yet at the same time, the condition of the environment is improved. For more information on land use, see Part 4.2: Land and Biodiversity.

Figure M19 Rock Lobster Fishery Western Zone (South Australian border to east of Cape Otway) - historic available biomass and projections under three management scenarios
Data source: Department of Primary Industries

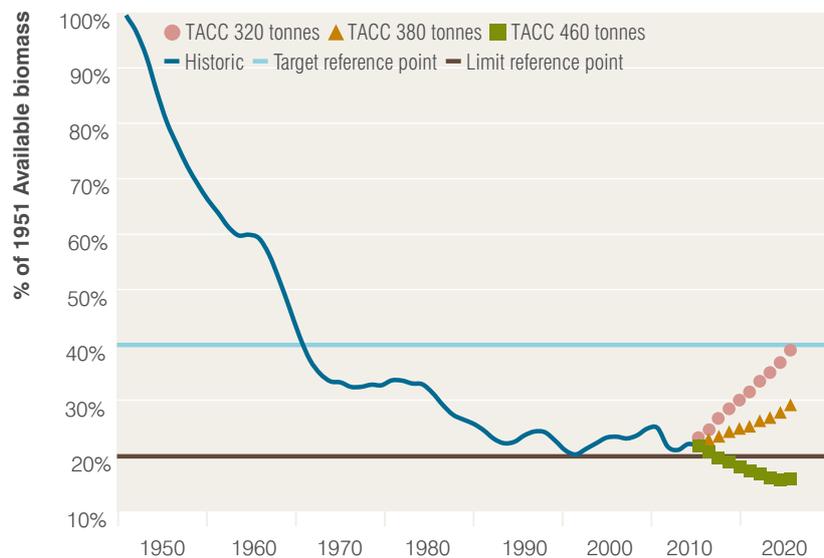
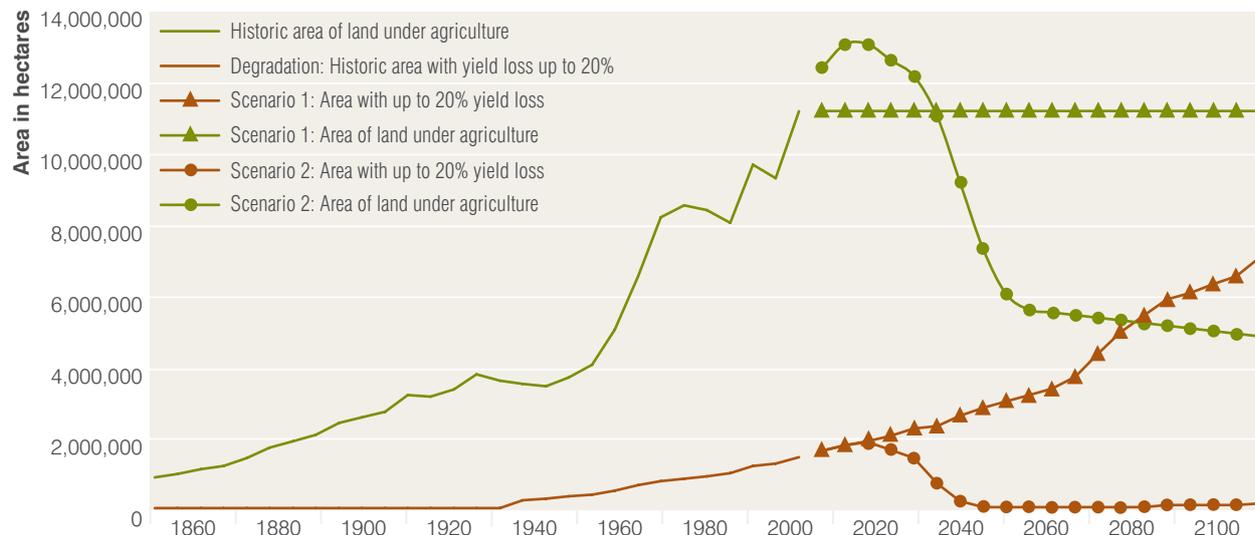


Figure M20 Modelling the effects of two different agricultural land management scenarios showing both the total area of land under agriculture, and the area of land subject to degradation under each scenario, Victoria
Data source: CSIRO



Summary

These hypothetical examples based on historic data illustrate the links between the mass of natural resource-based production (driven by demand for consumable items) and the state of natural systems.

More detail on the current state of the natural environment attributable to current and historic natural resource management practices is included in Part 4 of this report. In addition to fisheries biomass and land condition, Part 4 of this report considers indicators of soil and biodiversity health, the extent of fragmentation of habitats, modification of ecosystems, biodiversity and invasive species in describing the state of the natural environment.

Recommendations

M9 The Government encourage product manufacturers to use accredited environmental evaluation programs (such as LCA) to assess the level of resource depletion attributable to the manufacture of products.

M10 Governments in Australia continue to explore environmental labelling programs for high profile commodities that includes the use of resources throughout the entire manufacturing process.

Embodied energy and water

One of the most important reasons that increasing materials use is of environmental concern is that as use increases, so too can the use of resources invested in those materials. The use of energy and water, depending upon how they are sourced, can cause pressures on the environment. Of particular significance are greenhouse gas emissions associated with energy production, and the impact on environmental flows associated with water extraction (see Parts 3.1: Energy and 3.2: Water Resources).

Embodied energy and water indicators are systems concepts that illustrate the relative amounts of energy and water that have been invested 'into' products during production stages such as resource extraction, manufacturing and transport. Embodied energy and water are single metrics and should not be used as the sole basis for decision-making. Trade-offs between water and energy, and other issues of concern (include social) are always required, and need to be made explicit if decision-making using these metrics is to be undertaken. Therefore, while there are limitations inherent in the use of the concepts, embodied energy and water analyses can be used to infer the amount of energy and water that will be lost if a product is not used efficiently, is wasted, or is not recycled.

In turn, accounting for embodied energy and water in production and consumption processes is an essential component of lifecycle analyses, which can then be used to inform the choice of the most environmentally friendly product for a particular task and to ultimately reduce the resources required for production.

Embodied energy

Embodied energy is the cumulative energy demand⁸⁵ of a product, incorporating all energy used to obtain primary resources, manufacture, package and transport of the product. Other terms are *virtual*, *hidden* or *embedded* energy. Embodied energy does not include the energy required to operate the product, although embodied energy can affect the amount of operating energy that is required. The figure below shows how components of embodied energy fit into a holistic lifecycle analysis.

Embodied energy indicators are relative measures and, as with a full LCA, they require a functional unit that is relevant to the product in question (for example per tonne of steel or per 200 gram can of sardines) to be defined. Because energy use is closely associated with environmental pressure, estimates of embodied energy are sometimes used as a proxy indicator for the total environmental impact of a product or material⁸⁶, although care should be taken when doing so.

One example which can be used to illustrate embodied energy burdens is that of fresh food produce. The growth in global trading means that consumption of particular produce is now often not limited by local seasons. Produce is imported from around the world according to demand. However, the additional energy required to process, package and then transport food, sometimes hundreds or even thousands of miles to the table, may account for a significant proportion of its environmental impact.

Estimates of *food miles* by the Centre for Education and Research in Environmental Strategies (CERES) show the greenhouse impact of energy used in the transport segment of the supply chain of some common food products consumed in Melbourne.

Figure M21 Energy may be embodied into a product at a number of supply chain steps, five of which are shown here

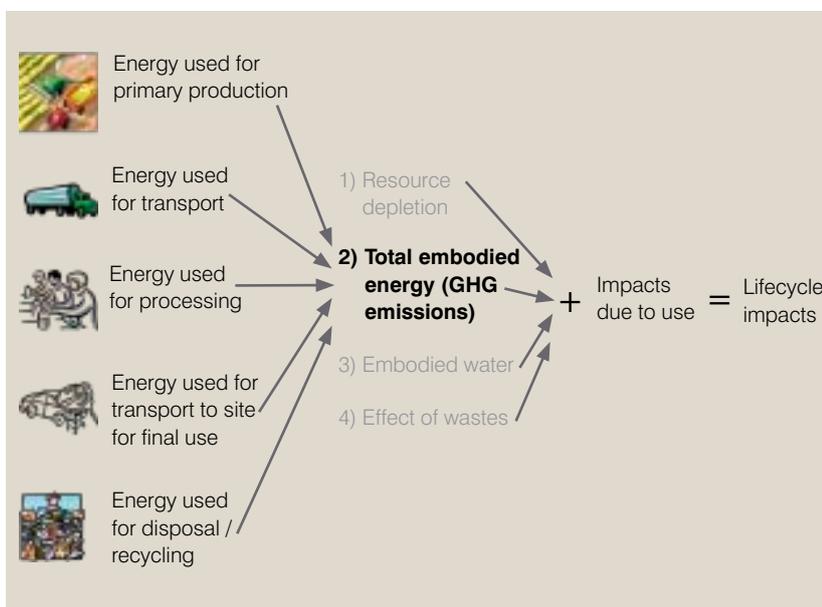


Figure M22 Estimated GHG in CO₂ equivalent attributable to the road transport of 1 kg of product
Data source: CERES (Centre for Education and Research in Environmental Strategies)

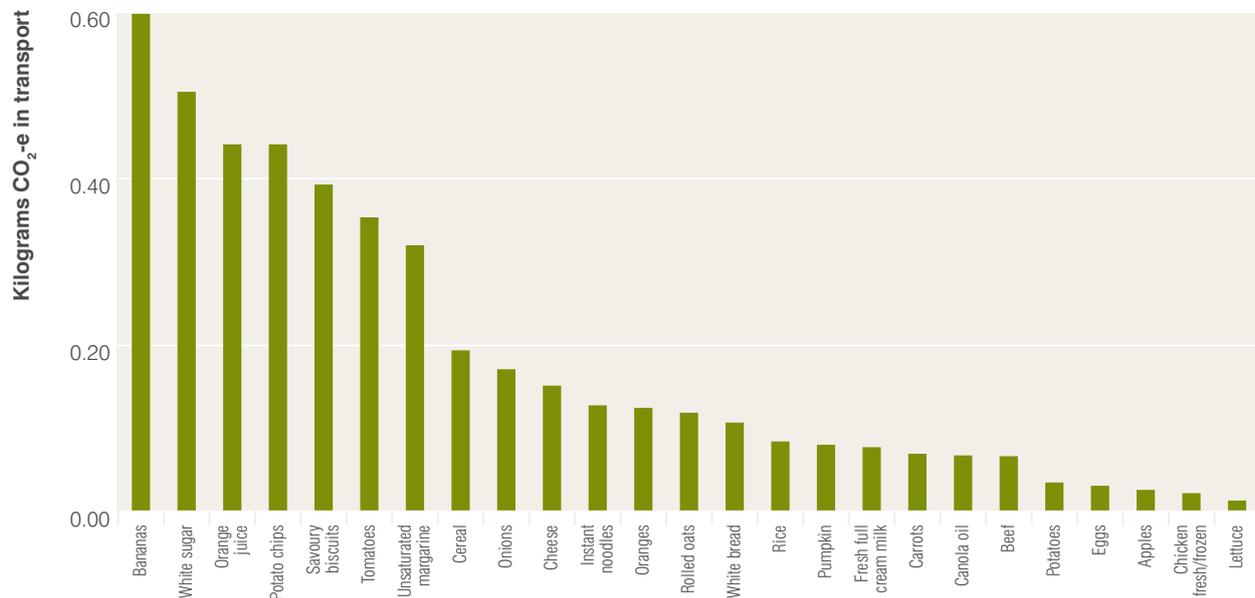


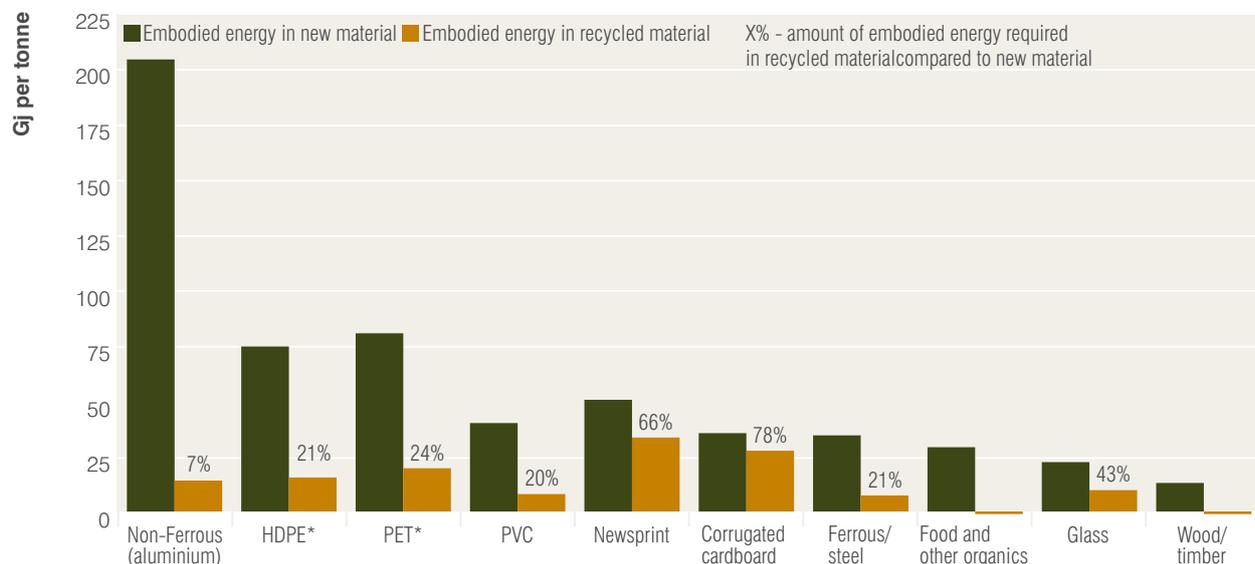
Figure M22 shows that greenhouse gas (GHG) emissions attributed to energy embodied during transport vary greatly. This is primarily a function of the region in which the food is grown and the method used to transport it to Melbourne⁸⁷. Not shown are imported foods and those that use packaging (for example, coffee or chocolate) that itself requires transportation. These will have higher levels of embodied energy and therefore, depending upon the fuels used for transport, higher levels of attributed greenhouse gas emissions.

It is important to note that energy embodied during transport is only one component of an item's total embodied energy, total embodied energy itself being only one component of the total pressure of an item (see Figure M21). It is also important to note that energy embodied during transport is not distinct from the use of energy in transport that is covered in Part 3.1: Energy. Rather, it attributes the energy used in freight transport to specific material products.

Recycling is an important way in which the energy embodied into manufactured

products can be conserved. Figure M23 shows the difference between the levels of embodied energy of a range of common materials when they are made from raw material or recycled material^{88,89}; i.e. at a stage when they are ready for use in manufacturing (for example, aluminium sheet used for making aluminium cans). For items made from recycled materials, this includes the energy used for collection and sorting.

Figure M23 Typical levels of embodied energy in common materials, new and recycled^{xi}
Data sources: Warneken ISE, RMIT



^{xi} HDPE=High density polyethylene; 'number 2 plastic' (for example, from which two litre milk bottles are made).
PET=Polyethylene; 'number 1 plastic' (for example, from which soft drink bottles are made).

As in the case of *food miles*, it is important to note that energy embodied in the manufacture of products is not distinct from the use of energy in the manufacturing sector (see Part 3.1: Energy). In summary, embodied energy, although 'hidden' from the consumer, may constitute a significant component of a product's total ecological footprint. It will also vary according to the amount of recycled content used in the product, the transport used in production and distribution, and various other factors in the manufacturing and supply chain. At present, embodied energy information is not widely available; provision of this information would allow manufacturers and consumers to compare and choose processes and products according to this important environmental criterion.

Embodied water

Similar conceptually to embodied energy, the term *embodied water* refers to the amount of water that is required to deliver a product or service from the primary resource stage to its point of use. Water embodied 'into' products remains within the water cycle, but its extraction from rivers and aquifers can cause pressures on the environment (see Part 3.2: Water Resources). For food, the greatest proportion of embodied water is attributable to the agricultural sector, which currently consumes over 75% of Victoria's total available water (see Part 3.2: Water Resources).

In cases where water use is an important component of total environmental impact, estimates of embodied water are sometimes used as a proxy indicator for the total environmental impact of a material or product. When this approach is used, care should be taken to ensure that other pressures attributed to a product are not trivialised.

The typical amounts of embodied water in some common products (averaged for all world economies) have been estimated by the UNESCO Water Footprint⁹⁰. These figures indicate the amounts of water needed to supply products to a point where they are ready to be consumed.

Figure M24 Water may be embodied into a product at a number of supply chain steps, four of which are shown here

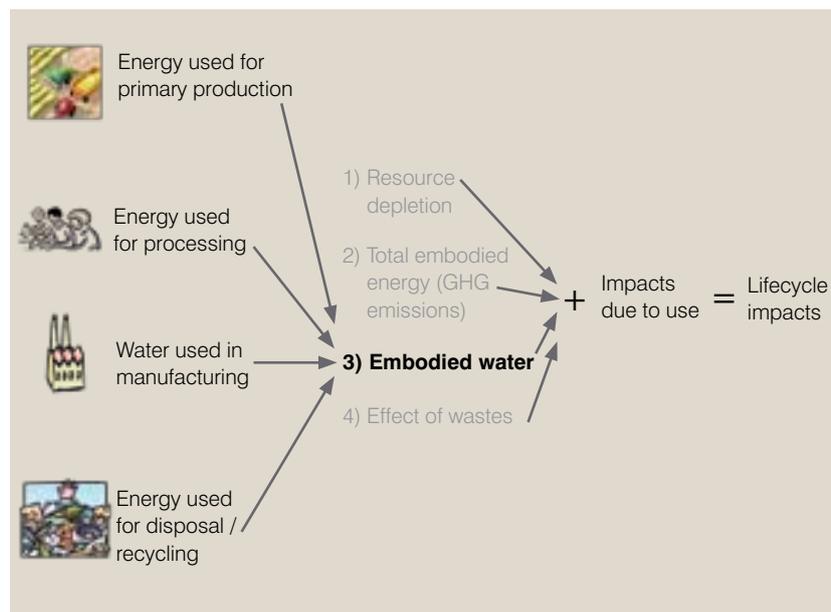


Table M1 World average estimates of embodied water for 20 common consumable items
Data source: Hoekstra & Chapagain⁹¹

Product	Functional unit of Product	Embodied water content (litres)
1 pair of leather shoes	1 pair	8,000
1 hamburger	150 g	2,400
1 cotton T-shirt	250 g	2,000
1 glass of milk	200 ml	200
1 glass of apple juice	200 ml	190
1 bag of potato crisps	200 g	185
1 glass of orange juice	200 ml	170
1 cup of coffee	125 ml	140
1 egg	40 g	135
1 glass of wine	125 ml	120
1 slice of bread + cheese	30g + 10g	90
1 glass of beer	250 ml	75
1 apple	100 g	70
1 orange	100 g	50
1 slice of bread	30 g	40
1 cup of tea	250 ml	35
1 microchip	2 g	32
1 potato	100 g	25
1 tomato	70 g	13
1 sheet of A4-paper	80 g/m ²	10

It is important to note that these figures are globally typical embodied water values. If two items of the same product made in different countries or in different parts of Victoria are compared, the embodied water factors will differ according to the agricultural and processing practices in use.

The Victorian Water Trust has estimated Victorian-specific embodied water factors for 136 products and services, per dollar sold^{xii}.

The results of this analysis show that of all the products and services studied, Victorian-grown rice is the most water intensive product, although the total amount of water used by this industry is quite low as only a small amount of rice is grown in Victoria. Dairy products are listed as the second-most water intensive products, and, among the products listed, requires the greatest volume of water for production.

Given the important export role that Victorian agriculture plays, the water embodied in export products is effectively a form of water export. It is estimated that in 2005–06, 32% of the total streamflow in Victoria was harvested⁹³. Of this harvested water, around 40% (2,000 GL) was exported out of the State as embodied water, mainly in food products⁹⁴. When considering targets for growth in agricultural exports⁹⁵ it is important to take into account the implication of increasing the amount of water embodied into exports with declining water availability (See Part 3.2: Water Resources).

Analyses of embodied water also show that personal lifestyle choices that drive demand can influence water demand from agriculture. For example, dairy products, red meat and sugar generally have a relatively high embodied water demand whereas foods that are often recommended as healthy options, such as fruit, vegetables, grains and seafood, tend to have much lower water requirements. According to the methodology used to perform this particular analysis, a vegetarian diet typically has half the embodied water content of a standard, meat-rich diet⁹⁶.

Summary

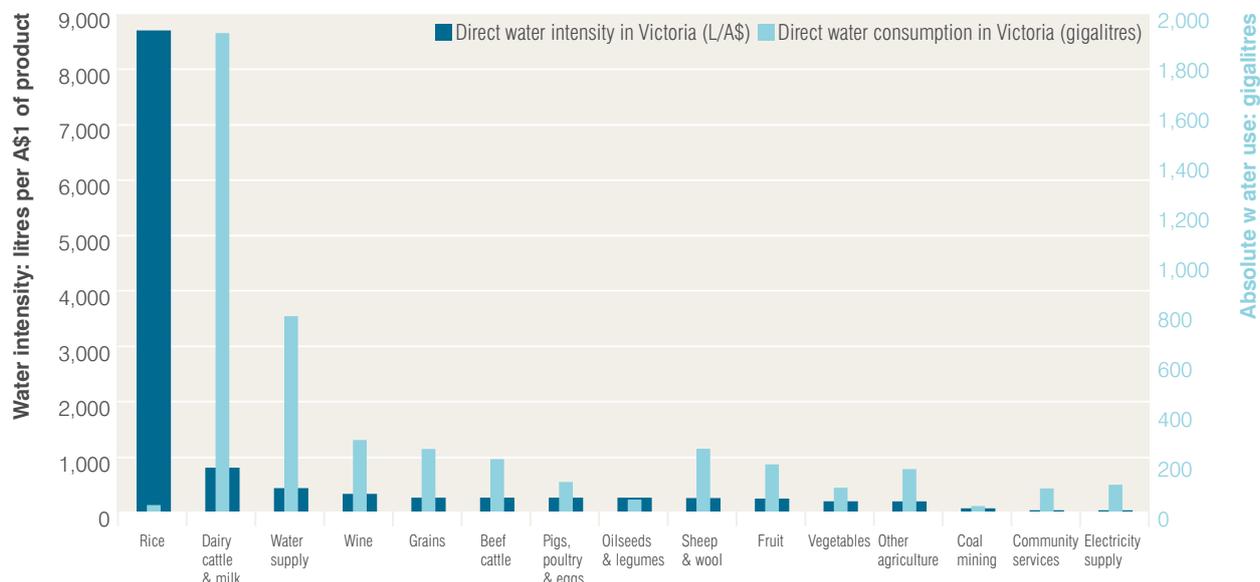
Analyses of embodied water and energy can provide useful information on the resource efficiency of the primary industries, manufacturing and transport systems used to bring products to their point of consumption. They can also be useful for informing choices, according to environmental criteria, between products that provide the same or a similar service. However, these analyses are complex, and consideration should also be given to both the absolute level of resource use as well as to indicators of other environmental impacts (as in a full lifecycle assessment) in order to provide a complete picture of the environmental pressure incurred by a product or service.

Recommendations

M11 The Victorian Government encourage industry to use accredited environmental evaluation programs (such as LCA) to assess the level of embodied energy and embodied water in products and to develop more efficient processes.

M12 Governments in Australia continue to explore environmental labelling programs, for high profile commodities, that includes energy and water embodied into the products during the manufacturing process.

Figure M25 The fifteen Victorian products or services with the highest levels of embodied water per dollar value at consumption in blue, compared with total water use
Data source: Victorian Water Trust, GHD Consulting⁹²



xii This analysis draws a distinction between supply chain steps. For example, *dairy cattle & milk* is attributed with a higher value for embodied water than is *dairy products*, as embodied water is attributed to the step in the supply chain where the sale of the commodity occurs.

Environmental pressures of waste

In the context of the entire supply chain, general non-hazardous waste that is managed using modern waste management technologies and practices generates few environmental pressures relative to those associated with production, transport and operation. Nevertheless, opportunities to further reduce these impacts should continue to be explored.

More significantly, as long as material products are produced, consumed and disposed of, there exists a constant demand for new sources of material, as well as more embodied energy and water, to replace the old. Thus, where full environmental consideration is not given to materials, its disposal (waste) can also represent an opportunity cost, with implications for the entire value chain. These implications are more significant than those associated with any environmental pressures occurring at the point of disposal alone.

Wastes are most often only thought of as the final stage of a product's life, but in fact waste is generated at all stages in the supply chain of products and by all industries – including primary industries (see Figure M5). In the home, waste includes plastics of many types as well as organic matter, glass, paper, steel and aluminium. These constitute both materials that are recyclable as well as non-recyclable. As is the case for other sectors, the way that a household manages its waste can be of benefit to the efficiency of material flows or, contrarily, can lead to environmental pressures.

In the primary industries, depending upon whether it is actively managed, overburden from mining can be classified as a 'hidden' flow – a waste product or a useful resource in itself. Overburden that is not well managed can have impacts on topography, hydrology and biodiversity. Similarly, in agriculture, manure can also be classified as a waste and, if poorly managed, can pollute waterways, generate greenhouse gases and impact health (see Hidden flows).

A large proportion of waste comes from secondary industries such as manufacturing and construction, some of which is potentially hazardous. Poor planning in design and assembly can lead to inefficient use of resources in manufacturing or construction, leading to unnecessary material waste.

The management of such waste can be an economic burden which is passed on down the supply chain of products, increasing the price to the consumer. In the case of construction, poor design can not only create unnecessary material waste, but also a legacy of inefficiency throughout a building's life (see Part 3.1: Energy and Part 3.2: Water Resources).

Alternatively, 'waste' products may be useful resources for other industries. For example, overburden can become fill for landscaping, and manure can become

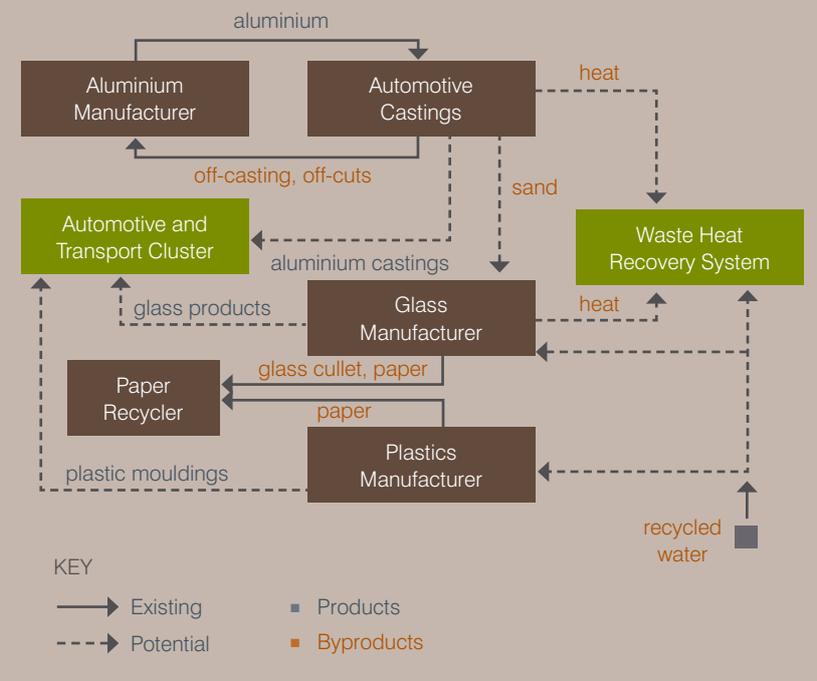
fertiliser for agriculture – or even a bio-energy source for electricity generation. In industrial ecology (see Box M3)⁹⁷, the waste output from one manufacturing process is used as the feedstock or input into another. Similarly, wastes from households can be re-used, recycled or composted, thus increasing their utility. Such practices of 'eco-efficient' resource use divert materials from 'waste', also preventing the need for them to leave the economy, making them available to other stages of the economic value chain.

Box M3 Industrial Ecology case study - The Dandenong Logis

Dandenong Logis, by VicUrban, is being developed according to industrial ecology principles, where a community of businesses enjoy a greater, collective economic and environmental benefit than the sum of the benefits each would realise by optimising its own performance alone⁹⁸. At Dandenong Logis, several

companies, including PolyPacific, BOC Gases, NorStar, Visy and Pilkington, have been identified as potential players in an industrial ecology complex⁹⁹ with the potential synergies of local eco-industrial complexes contributing towards the creation of a cleaner, less wasteful, more sustainable society¹⁰⁰.

Figure M26 Existing and potential synergies at Dandenong Logis industrial ecology development
Data source: Batten et al.¹⁰¹



The environmental impacts of 'waste' will be minimised both by increasing the efficiency of materials flows and by reducing total material flows. Studies indicate that there is almost always a net environmental benefit when material wastes are recycled compared to when sent to landfill, even when the energy used to transport and remanufacture the material is taken into account¹⁰² and when methane gas capture from landfills is performed. Further use of extended producer responsibility (EPR) programs (such as the e-Waste programs ByteBack and BatteryBack¹⁰³ and CDL (see Unmanaged wastes, below) that provide incentives for dematerialisation, refurbishment and recycling are of high priority, especially as technological advances increase the complexity of consumer products (See Part 2: Driving Forces). Full EPR programs that do this by internalising the cost of 'waste management' at the manufacturing stage of products are also to be strongly encouraged.

Some of the environmental pressures most directly associated with waste include:

- greenhouse gas emissions and pollution of groundwater from landfill
- the energy used by recycling industries
- hazardous and other waste and its impacts on amenity and health
- the affect of unmanaged outputs such as litter and dissipative wastes.

These are covered in the following sections on landfill, recycling, prescribed waste and litter.

Landfill

After recycling, landfill is currently the waste management technique most often used, with about 38% of all waste managed via this method (see Figure M18, above). Landfills are defined as 'the deposit of waste onto and into land'. For a *sustainable landfill* the following could be added: 'in such a way that pollution or harm to the environment is prevented and, through restoration, land is provided which may be used for another purpose¹⁰⁴.

There are 85 licensed landfills in Victoria, and around 100 unlicensed landfills, most of which are council owned. Landfills serving communities of less than 5,000 do not require licences in Victoria unless they receive prescribed waste. Mallacoota landfill, for instance, is licensed because it receives abalone wastes that can affect amenity¹⁰⁵.

The most significant environmental pressure directly attributable to landfills is the emission of the greenhouse gas, methane, by the anaerobic decomposition of putrescible waste. Methane is a greenhouse gas of concern, is a non-toxic asphyxiant and can be hazardous due to its flammability. In most cases, landfill gas is adequately contained according to State Environmental Protection Policies, or is combusted for the generation of energy. In rare cases, such as at the disused, unlined Cranbourne Landfill site in 2007-08, methane can escape from a landfill and negatively affect local health, safety and amenity such that expensive remediation is required.

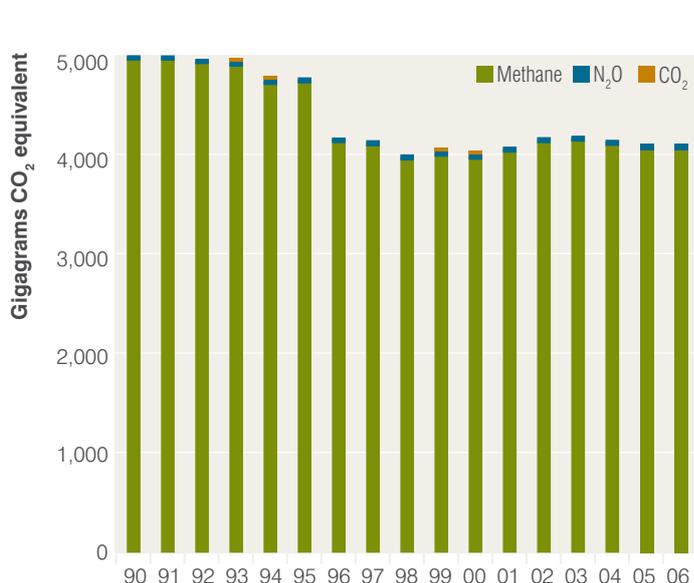
The Victorian Greenhouse Gas Inventory (VGGI) shows that the solid waste management sector emits approximately 3% of Victoria's total greenhouse gas (GHG) emissions (see 4.1: Atmosphere – Climate change). Over 96% of this comes from landfills and is methane (the less than 4% remainder is attributable to incineration and other waste management methods)¹⁰⁶. The 16-year trend of GHG emissions shows a decline that corresponds to increasing recycling rates¹⁰⁷ and also partly to the increase in the utilisation of methane from landfill for energy generation¹⁰⁸. This is an encouraging trend and is expected to continue as more waste is diverted from landfill to efficient material recovery processes and as capture of landfill gas becomes more widespread and effective.

Every tonne of waste to landfill represents a tonne of material that is no longer able to contribute to the economy. A conservative commodity value of over \$280 million worth of materials was disposed of in Victorian landfills during the period 2005-06¹⁰⁹. A sample landfill analysis (covering all material disposed at six landfills in a normal week) was conducted in 2005 (see Figure M28a).

Figure M28a shows that a large proportion of waste disposed by landfill is re-usable or recyclable (including compostable) using current technologies^{xiii}. Preventing waste from entering landfill by re-using and recycling maximises the value of material, reducing the need for further extraction of material from the environment. This helps to protect natural resource stocks and can also potentially reduce amenity risks that can be associated with landfills.

Apart from GHG emissions and the opportunity cost of landfill, other pressures from landfills include the risk of contamination of groundwater by leachate and reduced amenity in areas near landfill facilities predominately due to noise, dust, litter and odours¹¹¹. Of 212 contaminated sites designated for remediation by the EPA's Priority Sites Register, 61 are former landfills and only four are current landfills. This would seem to indicate an improvement in the management of potentially hazardous waste and the management of landfills¹¹².

Figure M27 Trend in GHG emission from waste by type, Victoria, 1990–2006
Data source: Victorian Greenhouse Gas Inventory



xiii Recent garbage bin audits show that a large proportion of the *domestic kerbside garbage* category consists of food organics.

Figure M28a Composition of waste to landfill (by weight) 2005
Data source: Sustainability Victoria¹⁰

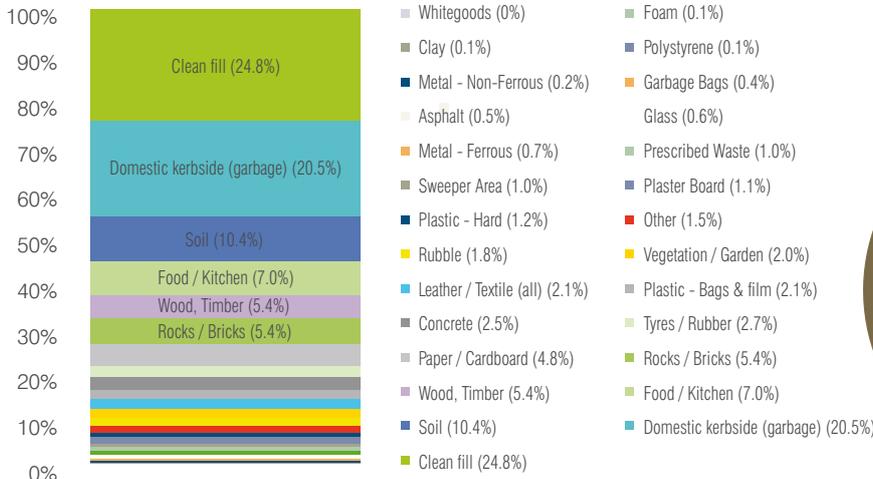
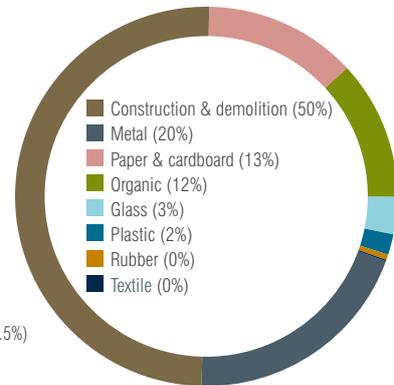


Figure M28b Proportions of waste by type actively managed via recycling, 2006–07
ecology development
Data source: Sustainability Victoria¹⁵



Recommendation

M13 The Government explore opportunities for systematically raising the standard of environmental management of landfills. The government consider banning the landfilling of materials for which resource recovery systems currently exist. The government provide incentives to resource recovery industries to explore further market opportunities for increasing the utility and value of recyclable materials.

an important factor when natural resources are in limited supply or their extraction or production creates other impacts on biodiversity.

Figure M28 shows that in 2004-05, 46% of all material recycled in Victoria was from the building industry (predominantly concrete), followed by metals (21%) and paper (17%). Organics were 11% of the total and all other sub-groups (glass, rubber, plastic and textiles) comprised just 4% of the total.

Currently, the government, including local councils, plays a major role in providing and supporting recycling and other resource efficiency programs.

There is scope for industry, business and consumers to take greater responsibility for materials efficiency through the use of product stewardship programs such as EPR (of which *container deposit legislation* is an example) that internalise the environmental and resource costs of material flows into production and consumption.

Recommendations

M14 The Victorian Government investigate ways to further apply extended producer responsibility programs (EPR) with the long-term goal of programs that cover all material products.

M15 The Victorian Government expand analyses of waste to landfill to identify opportunities for increasing material recovery rates in order to reach the stretch target outlined in Recommendation M8.

Recycling

There are 50 materials recovery facilities (MRFs) collecting and redistributing material for recycling in Victoria. As with landfills, recycling facilities have environmental pressures associated with their operation; for example, there are GHG emissions attributable to electricity use. However, taking into account the value of the embodied water and energy that is preserved through recycling, these impacts are significantly lower than those associated with landfill¹³. For example, the active management of aluminium 'waste' via recycling makes the material available to the economy again, requiring only one fourteenth of the energy that would be required to refine new aluminium from raw materials (see Figure M23, above)¹⁴. Given that energy generation and use in Victoria is associated with significant environmental pressures, the recycling of energy intensive materials such as aluminium is an important way to reduce energy use. Recycling also contributes to the conservation of resources themselves,

Prescribed waste

Prescribed wastes are potentially hazardous wastes, or wastes that may affect amenity (for example, due to odour), and as such require special management. In 2006, almost 500,000 tonnes of prescribed waste was disposed to landfill in Victoria, a 22% decrease since 2000. The high hazard waste was disposed of at the Tullamarine and Lyndhurst landfills and the low hazard waste was sent to around 25 landfills throughout the State that are licensed to accept specific low hazard waste streams¹¹⁶ such as low level contaminated soil, packaged waste asbestos, or wastes that impact on amenity (for example, seafood processing wastes).

Prescribed wastes are to be managed in accordance with the waste management hierarchy, where the preferred order of management is avoidance, reuse, recycling, recovery of energy, treatment, and, finally, containment or disposal where no alternative exists. In accordance with this, prescribed waste should be treated where necessary to reduce its hazard to acceptable levels prior to landfill disposal¹¹⁷.

There has been a declining trend in the disposal of manufactured prescribed waste since 2000. This can be attributed to increasingly high standards of cleaner production in industry, investments in improved technologies, process improvements and also greater recovery of wastes through reuse, recycling and energy recovery¹¹⁹. The recent increase in disposal of contaminated soil (a legacy waste) is attributed to the recent (July 1, 2007) landfill levy rise payable for the disposal of prescribed industrial waste, where the pending cost increase stimulated contaminated land remediation and resulted in an elevated quantity disposed to landfill when compared to annual averages¹²⁰.

In January 2007, the Government announced an accelerated prescribed waste reduction strategy. Further information in relation to its ongoing implementation can be found at the EPA website: http://www.epa.vic.gov.au/waste/prescribed_waste.asp.

Recommendation

M16 The Victorian Government annually increase the prescribed waste levy with funds raised targeted towards resource recovery and clean industry programs.

Unmanaged waste

– Litter and dissipative outputs

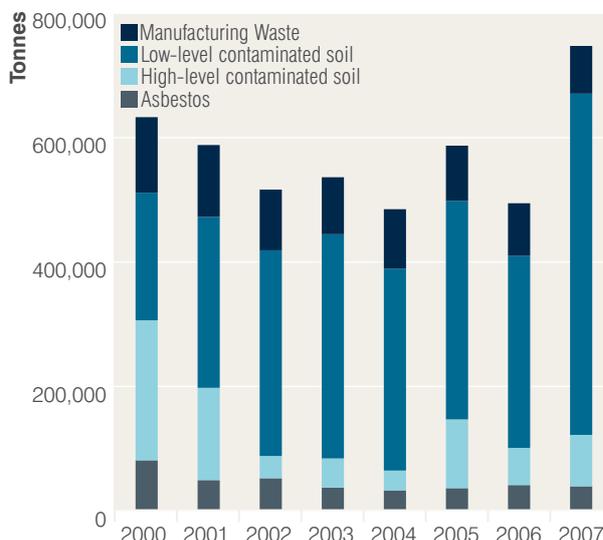
Litter is an environmental and a social problem. It diminishes the image of communities, is costly to clean up, and is often washed into the sea through drains, creeks and rivers. Litter, including plastic bags, that collects on streets can also block drains and lead to flooding¹²¹. Freshwater and marine animals can be injured or killed by litter and stormwater pollution, either due to entrapment, ingestion or due to toxic chemicals in litter¹²². If it is collected, as most litter is not recycled, it also represents an opportunity cost, as the resources invested during the manufacture of material that is littered (i.e. embodied water and energy) are not made available to the economy again. Anti-littering legislation exists, but due to costs and practicalities, is not easily enforceable.

The Victorian Litter Report and Keep Australia Beautiful Council's National Litter Index (NLI) both provide counts of the number of items littered. From the NLI it is estimated that, averaged across Victorian urban environments, 77 litres of litter is dropped and accumulates per square kilometre before it is removed by weather or the municipal authority¹²³. As a component of this total, rubbish dumping is believed to be on the rise¹²⁴. Container deposit legislation (CDL), a form of extended producer responsibility (EPR), has the potential to reduce the

incidence of certain types of packaging that are often littered. However, due in part to the extensive domestic kerbside collection system that has been developed over the last twenty years, the cost of CDL is currently deemed to outweigh the benefits¹²⁵. This should be strategically reviewed as soon as is practical or during the mid-term review of the National Packaging Covenant, as CDL has the potential to reduce litter, but also to raise community awareness of the wider application and value of EPR. For example, implementation of ESAS Action 10.1 – Banning plastic bags, has been slow, although recent (October 2008) trials have been encouraging. This Action would be facilitated through better community and business understanding of the merits of EPR.

Data for dissipative outputs are currently not measured outside of lifecycle assessments, where they are quantified as a component of a product's environmental impact. Nevertheless, the impact of total dissipative outputs can be significant, especially if hazardous to health and life. Total amounts of certain dissipative outputs are covered in Parts 3.1: Energy and 4.1: Atmosphere.

Figure M29 Trend in disposal of prescribed wastes at Tullamarine, Lyndhurst and other landfills
Data source: EPA¹¹⁸



Recommendations

M17 The Victorian Government investigate further opportunities to actively enforce current anti-littering legislation and review the effectiveness of current anti-littering legislation.

M18 The Victorian Government review the viability of container deposit legislation and other EPR programs, including the recently successful plastic bag levy trial.

Summary

Waste is produced at all stages in the supply chain of products and services and, depending upon the way it is managed, it is associated with a number of different environmental impacts. Industrial processes are able to transform natural resources into final products for consumption with increasing levels of complexity. These industrial transformations require energy and water, which represent important resource investments into materials. When materials are not reused, recycled or used efficiently there is an opportunity cost, as the energy, water and the material itself can no longer be used to contribute to the economy. Further, due to the complex nature of material transformations, many of the substances that are produced are not able to be readily metabolised by the natural environment and may harm natural systems.

Environmental management of waste, including landfills, recycling processes, management of prescribed waste and litter prevention, can greatly reduce these impacts. However, it is of equal importance that the amount of material throughput in the final 'waste' stage of the supply chain, as well as each of the preceding stages, is reduced.

Recommendations

M19 The Victorian Government encourage product manufacturers to use accredited environmental evaluation programs (e.g. LCA) to assess the level of environmental pressure attributable to waste flows of products.

M20 Governments in Australia continue to explore environmental labelling programs for high profile commodities that includes information on the level of environmental impact due to waste outputs attributable to each product.

Box M4 Lifecycle assessment and ISO methodology

Lifecycle assessment (LCA) is an internationally recognised approach to evaluating the environmental impacts that are attributable to a single service or a product throughout its lifecycle. LCA can be used to identify the environmental impacts from raw materials extraction and processing through to end-of-life. The International Organisation for Standardisation (ISO) has standardised the methodology for LCA within the series ISO 14040 and stipulates that both the scope and the functional unit of the LCA are defined. The **scope**¹²⁶ of an LCA typically includes:

- material production processes from raw material extraction and energy conversion, including fuel production
- transport processes, including fuel production
- processes that occur during distribution and use
- waste treatment. Useful products such as energy and reclaimed materials are also taken into account.

It often does not include:

- capital goods such as production

equipment and transport equipment

- human labour and, for instance, transport of the workforce between home and work. However, the displacement of the service personnel is sometimes included
- accidents
- industrial packaging
- noise
- biodiversity.

The **functional unit** of an LCA provides a reference to which the impacts of the product or service can be related¹²⁷. Depending upon the purpose and audience of the LCA, a kilogram of material (for example, a one kilogram ingot of aluminium) may be an appropriate unit. When undertaking LCA of everyday products it may be useful to use a recognisable product in conjunction with the service that it provides as the functional unit; for example, a can of lemonade. Including the service as a component of the functional unit enables alternative means of providing the service to be considered (product substitution).

Lifecycle assessment – Case studies

A lifecycle assessment is the investigation and valuation of the environmental impacts of a given product or service. Like embodied water and energy, it is a systems analysis, as it attributes a defined proportion of the impact of the product's entire value chain to that item. LCA is often used to analyse information on the extent to which a product or service contributes to:

- resource depletion
- embodied energy and water demand
- environmental impacts due to use or operation of the product
- environmental impacts due to waste and pollution.

Similar to intensity indicators such as embodied water and embodied energy (which are effectively components of LCA), the LCA methodology requires that a functional unit is defined (see M4).

The way that products are designed (for example, their durability), assembled (including the waste that is generated during manufacture and construction), used and disposed of all affect the LCA result. Results from the LCA provide information on the *relative* environmental impact of a product. It can then be used to compare the environmental implications of different products that nominally provide the same service. There is scope for the LCA method to be used for comparing quite complex products, as long as the functional unit is identified carefully and applied consistently, and for informing extended producer responsibility (EPR) programs.

Lifecycle analysis is widely used in industry to compare the environmental implications of everything from pens to aeroplanes. In many cases, due to commercial-in-confidence requirements, the results of LCA analyses are not publicly available. Two lifecycle assessment case studies are used here to provide examples of the way in which environmental pressures can be attributed to the production and consumption of products.

Case study 1 – A packet of corn chips

An LCA for a packet of corn chips was conducted for the Grain Research and Development Corporation and the Australian Greenhouse Office¹²⁸. In this case the functional unit was the corn chips and packaging (405g). The scope of the assessment included all processes directly attributable to the production and decomposition of the packet of corn chips, from growing the maize through to the final product and its disposal, excluding transportation. The processes are shown as a flow chart inside the box in Figure M30. The resource inputs and waste outputs are shown outside the box.

The lifecycle implications of a packet of corn chips are broken down into six major groups. Three of these are inputs: 380 litres of water, 6.8 megajoules of energy and 0.3722m² of land. The other three are outputs: 525.0 grams of greenhouse gas, 2 grams of nitrous oxide and 0.1 gram of particulate emissions.

Figure M30 Scope of the LCA for a packet of corn chips
Data source: RMIT²⁹

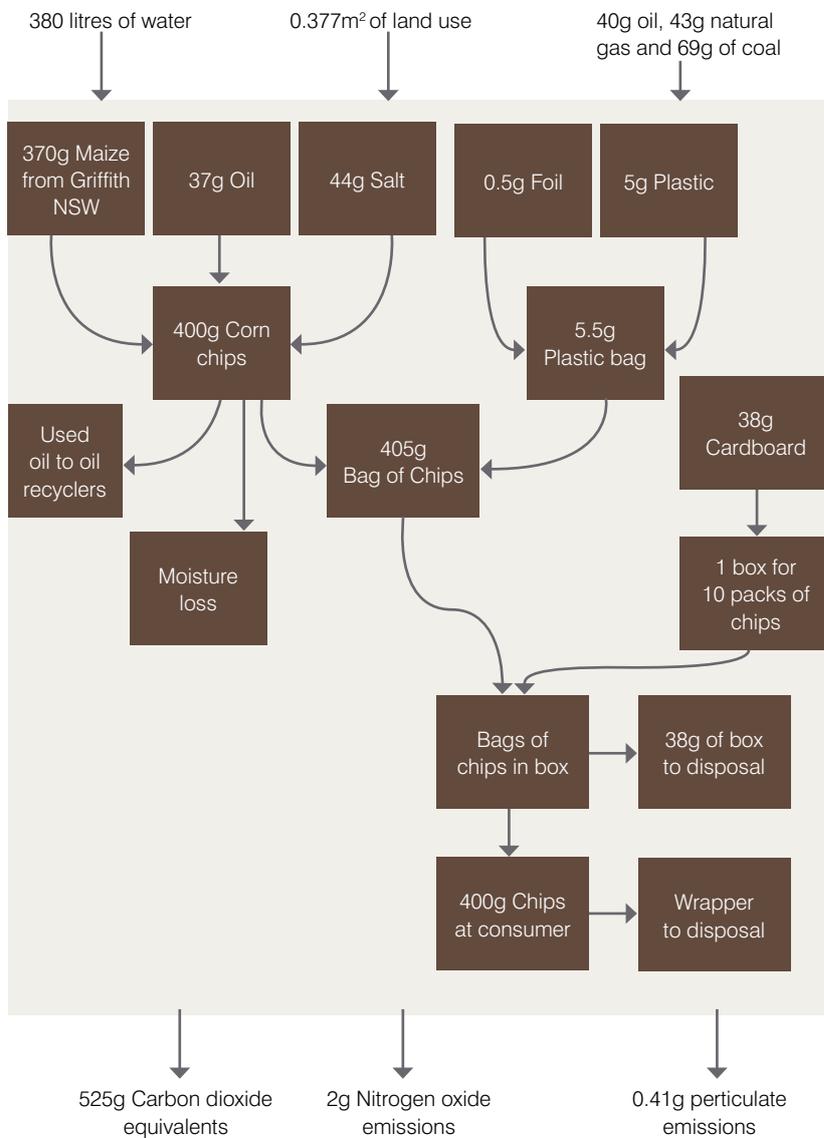


Table M2 Lifecycle analysis of a packet of corn chips
Data source: RMIT³⁰

Product	Outputs		
Water	380 litres embodied	Greenhouse gas	525.0 g CO ₂ -e
Energy	≈ 6.7 Megajoules embodied	Nitrogen oxide	2.0 g
-Oil	40g ≈ 1.3 megajoules	Particulate emissions	0.1 g
-Natural Gas	43g ≈ 3.8 megajoules		
-Coal	69g ≈ 1.7 megajoules		
Land	0.3722 m ²		

Case study 2 – Dulux paint

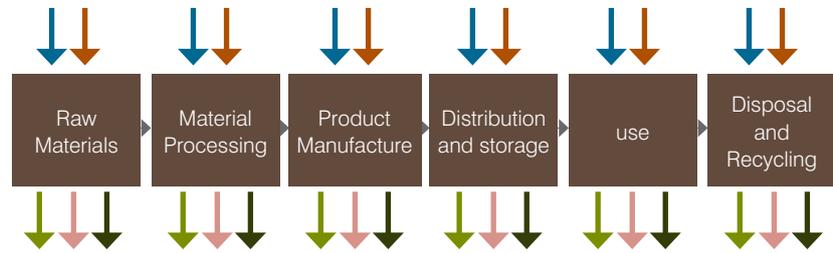
Orica and RMIT performed an LCA to compare the environmental effects of two decorative coating systems (paint), one water-based (Weathershield) and one solvent-based (Super Enamel)¹³¹. The scope of the LCA included all steps from extraction of the raw materials through to recycling and disposal (see Figure M31). In this case the functional unit was defined as 'the amount of paint required to cover a 100 m² pristine substrate with opacity of 98% over the span of 40 years'¹³².

The environmental impact of each product was evaluated using 10 environmental indicators (see Table M3).

Table M3 shows the relative extent of environmental pressures (including embodied water and energy) attributable to the two products, enabling a comparison to be made.

The results of the study show that overall, *Weathershield*, the water-based paint, offers a net environmental advantage, although for some of the indicators, the use of *Weathershield* incurs a greater impact.

Figure M31 Scope of the LCA comparing two Dulux products
Data source: Surface Coatings Australia



Inputs and outputs are identified with coloured arrows:

Raw Materials, Energy Resources, Emission To Air, Emissions To Water, Solid Wastes

Summary

The two case studies show the strength of the LCA technique in evaluating the total environmental impact of a product or service, especially in relation to another that performs the same function. Currently, despite the value of and need for LCA information suitable for making product and service comparisons, information on LCA analyses is not widely available. As understanding of the importance of decreasing the environmental impact of materials use grows, LCA will continue to be a key component in decision-making.

There are a number of programs in place that have the potential to raise

the profile of LCA as a robust method for rating products. These include the Australian Lifecycle Assessment Inventory Initiative (AusLCI.com) and organisations such as the Australian Procurement and Construction Council (APCC). In turn, knowledge gained via LCA of the environmental pressure attributable to particular products is essential to inform consumer choice via both eco-labelling programs and the rational pricing of consumer goods and services, or to determine which products should not be available for retail at all.

Table M3 Results of the LCA comparing two Dulux products
Data source: Surface Coatings Australia

Impact Category	Unit of measurement		Product 1	Product 2
			Super Enamel	Weathershield
Global Warming	kg	CO ₂	171.00	104.00
Acidification	kg	SO ₄	0.84	2.31
Eutrophication	kg	PO ₄	0.11	0.27
Heavy Metals	kg	Pb	0.00005	0.00017
Carcinogens	kg	B(a)P	7.75E-05	8.45E-06
Photo Oxidant Formation (Smog)	kg	C ₂ H ₄	12.00	0.48
Pesticides	kg	act.s	1.54E-06	0
Cumulative Energy Demand	MJ		4,010	2,360
Water Use	KL	H ₂ O	0.90	0.54
Solid Waste	kg		1640.00	900.00

Management Responses

Box M5 Eco-labelling programs

Eco-labels have the potential to provide consumers with accurate information on the environmental pressure incurred by consumables and can allow consumers to make judgements on the best product for a particular task according to environmental criteria. In the past there has been consumer uncertainty as to the value of eco-labels. This is due to a number of factors including the use of different criteria in labelling between agencies, lack of confidence in methods used to evaluate products, consumer prioritisation of other, non-environmental criteria in the selection of products, and the weak link between environmental awareness and purchasing behaviour¹³³. Some success has been achieved in Australia with the energy labelling of whitegoods, providing an excellent case study from which to further develop eco-labels into other areas of consumer products. There is currently a move by Sustainability Victoria and RMIT to streamline the delivery of programs designed to label consumer products and materials according to environmental criteria¹³⁴ as evaluated by robust methods such as LCA, and this is to be encouraged.

Recommendations

M21 The Victorian Government work with the Commonwealth Government to enhance the scope of the Australian Lifecycle Inventory Initiative (AusLCI.com) to a level that enables it to be applied to a wide range of high profile products.

M22 Governments in Australia lead industry in continuing to explore the development of robust eco-labelling programs to enable consumers to use sound environmental criteria to choose between products that provide the same or a similar service.

The preceding sections show that environmental pressures emerge at all stages of the production and consumption of materials. Therefore, policies and programs that aim to reduce the environmental pressures of materials use should do so by addressing these objectives:

1. Reduce environmental disturbance due to natural resource extraction and production processes. This is covered in Part 4 of this report.
2. Increase the efficiency of materials use at all stages of the production process, including reducing embodied energy and water.
3. Reduce the environmental pressures of waste disposal.

Policies and strategies that target the environmental pressures attributed to material flows operate within a number of different frameworks, including incentives, regulation and enforcement. Notwithstanding a wide range of local initiatives, this section provides a summary of key statewide policy initiatives intended to address the environmental impacts of products and services in Victoria.

The principal strategic department is DSE, undertaking the development and implementation of the Environmental Sustainability Action Statement, *Our Environment Our Future*. Sustainability Victoria is responsible for implementing materials flow management programs including Towards Zero Waste. The Victorian EPA regulates and enforces legislation to control waste as well as raising the profile of lifecycle assessment and the Ecological Footprint methodology as tools for understanding the environmental pressures of materials flows. The following describes some representative examples of these government programs within the context of the key objectives listed above.

Objective 2: Increase the efficiency of materials use at all stages of the production process, including reducing embodied energy and water

Response Name

Environmental Sustainability Action Statement (Our Environment Our Future)

Responsible Authority

Department of Sustainability and Environment

Response Type

Policy

Action 2: Improving our energy efficiency

Specifically, Action 2.1: Help for large resource users - mandatory waste efficiency audits for the state's 250 biggest energy and water users.

The Environment and Resource Efficiency Plans (EREP) program is a new regulatory scheme effective from January 1, 2008. It applies to Victoria's largest industrial and commercial users of energy and water. Sites that trigger the resource use threshold for utilities use must also develop an action plan targeted to waste reduction and must report on implementation of the plan. EPA has completed the drafting of EREP Regulations and an RIS (Regulatory Impact Statement) prior to implementation¹³⁵. As well as robust monitoring for best outcomes, EREP will benefit from the establishment of aggressive stretch goals for both materials efficiency and reducing total materials throughput. Longer term, such a scheme should be integrated into industrial and commercial enterprises of all sizes.

Action 10: Less waste and increased resource efficiency

Several of the initiatives in Action 10 are aimed at reducing the materials intensity of production and waste streams as well as minimising pollution. *Action 10.1: Banning plastic bags* is supported by an amendment to the *Environment Protection Act 1970*. An evaluation of the recent trials will provide further direction. Recent support from the Commonwealth Government¹³⁶ will also be beneficial, but given the nature of plastic bags as symbolic of both inefficient materials use, and the wider litter problem, further prompt action should be taken by the Victorian Government. *Action 10.2: Take back and recycling centres*, has seen the establishment of two permanent 'ByteBack' centres and six 'detox your home' centres, showing towards the target of 12 centres. *Action 10.3: Sustainable production and consumption taskforce* is currently undergoing project scoping. This taskforce has the potential to consider and address the wider and longer term pressures attributable to increasing materialisation in Victoria. It will need to critically evaluate the validity of the assumption that dematerialisation and improved efficiency generally will be sufficient to reduce the environmental pressure of material flows.

Action 10.4: The National Packaging Covenant now has 616 signatories Australia-wide¹³⁷ and has played an important role in diverting waste to landfill and continues to fund innovative materials efficiency and recycling programs. *Action 10.7: Support smart business* provides grants to Victorian businesses that demonstrate and apply leading thinking to deliver sustainable outcomes in energy, materials and water use, while *Action 10.8: Lifecycle management in business and industry* has seen the establishment of a website and other resources designed to help businesses use the lifecycle approach in the drive towards increased resource efficiency.

Each of these initiatives has an essential role to play in reducing the impact of materials flows. While these programs are targeted to increase material efficiency at certain economic segments and within certain industries, gaps remain, such that a more strategic approach and better coordination of programs would be beneficial.

Action 12: Increased water, energy and materials efficiency

Actions 12.1: Recognising business leaders and 12.2: Recognising sustainable products are both accreditation programs which award businesses and products with an environmental rating, enabling both consumers and business peers to recognise and choose more sustainable products. *Action 12.3 Sustainability in small and medium enterprises (SMEs)* brings resource efficiency standards into business start-up programs, thus raising the importance of materials efficiency in the community, while *Action 12.6: Enhanced sustainability in new investment* also encourages businesses that are expanding to consider materials efficiency and best practice waste management as part of any new development. Importantly, as more is learnt about resource efficiency through these programs, stretch goals that aggressively tackle the environmental implications of materials flow at each stage of the value chain will need to be integrated into such programs for real environmental benefit.

Response Name

Forestry Code of Practice and Our Forests, Our Future

Responsible Authority

Department of Sustainability and Environment

Response Type

Policy

2.1.2 Wood Utilisation Plans and Timber Release Plans. The Timber Pricing Review and CIP - Collaborative innovation program (Forestry).

These are examples of initiatives that are designed to facilitate the efficient use of natural resources; in this case, forest products. Through incentives for value-adding and improved reporting, they also provide a degree of certainty for forestry industries in the harvesting and utilisation of forest products. In conjunction with these, the CIP assists industry transition in response to programs that seek a reduction in the volume of materials produced from forests. There is great benefit in applying value-adding principles such as these to other primary industries.

Objective 3: Reduce the environmental pressures of waste

Response Name

Towards Zero Waste

Responsible Authority

Sustainability Victoria

Response Type

Program

Target 1 - A 1.5 million tonne reduction in the projected quantity of solid waste generated (across all sectors) by 2014.

Target 2 - 75% by weight of solid waste recovered for reuse, recycling and/or energy generation by 2014.

Target 5 - A 65% recovery rate (by weight) of municipal solid waste for reuse and recycling by 2014. An interim target of 45% is established for 2008-09. The recovery rate achieved in 2002-03 was 35%.

Target 6 - An 80% recovery (by weight) of commercial and industrial (C&I) solid waste for reuse and recycling by 2014. An interim target of 65% is established for 2008-09. The C&I recovery of 59% was achieved for 2002-03.

Target 7 - A recovery rate of 80% (by weight) of construction and demolition (C&D) solid waste for reuse and recycling by 2014. An interim target of 65% is established for 2008-09. The C&D recovery rate of 57% was achieved for 2002-03.

Given the trend in waste generation in the last decade, these are ambitious yet achievable targets towards which good progress has been made since 2004, particularly when compared with economic growth, and in regard to diversion rates (target of 75% by 2014), with the current rate estimated at 55%. The raised landfill levy (see Figure M32) will provide impetus for these goals, providing incentives to business to reduce the amount of waste generated and to develop innovative ways to increase materials efficiency.

As is the case for an emissions trading scheme, the rational pricing of processes that lead to environmental pressure, such as waste, is seen as an important step in reducing the extent of those pressures. In the case of waste, for best effect, the price should more accurately reflect its full environmental cost and the levy should be established, and communicated, in such a way that users of landfills are able to understand the nexus between what they pay and the environmental benefit of the funds raised (see also Part 5: Living Well Within Our Environment – Market-based instruments).

In terms of reducing absolute pressures, it should be noted that these waste reduction targets are against a base case that forecasts an expected increase in total waste generation and so do not necessarily represent a reduction in the absolute amount of waste generated. Furthermore, it remains to be seen whether the long-term target of a 1.5 million tonne reduction in solid waste generated will be reached, particularly given that there are no current programs specifically targeting increasing consumption – the precursor of waste generation.

Response Name

Environmental Sustainability Action Statement (Our Environment Our Future)

Responsible Authority

Department of Sustainability and Environment

Response Type

Policy

Action 10: Less waste and increased resource efficiency

Initiatives in Action 10 of *Our Environment, Our Future* that are specifically designed to reduce the impact of environmental pressures often attributed to the waste component of the supply chain include actions 10.2: *Take-back and recycling centres*, which will enable consumers to dispose of harmful household waste safely, and 10.6: *Hazardous waste*, which will raise levies from \$30 per tonne to \$130 per tonne (see Figure M32), thus providing an important incentive for business to reduce hazardous waste.

Action 10.10: Trade waste initiatives will support the environmental management of wastes that have in the past been dealt with by sewerage, and 10.11: *A minimum standard for detergent labelling* will enable consumers to choose a detergent according to environmental criteria.

Response Name

State Environment Protection Policy (Siting and Management of Landfills Receiving Municipal Wastes)

Responsible Authority

EPA

Response Type

Policy

Siting and Management of Landfills Receiving Municipal Wastes

Of importance is the *State Environment Protection Policy (Siting and Management of Landfills Receiving Municipal Wastes)*. This requires that planning, siting, design and management of landfills such that potential adverse effects to the environment, including contamination of surface waters and groundwater and potential health and amenity impacts on the community, can be avoided. Where these procedures are shown to be inadequate for the protection of local amenity, health and safety, and environmental values, higher standards should be set.

In terms of prescribed waste, as is the case for landfill, rational pricing is seen as an important step in ensuring that it is managed appropriately. Again, for best effect, the price should be based on the potential of the waste to harm the environment or human health.

Figure M32 Landfill levy increases 2001–2008

Data source: EPA

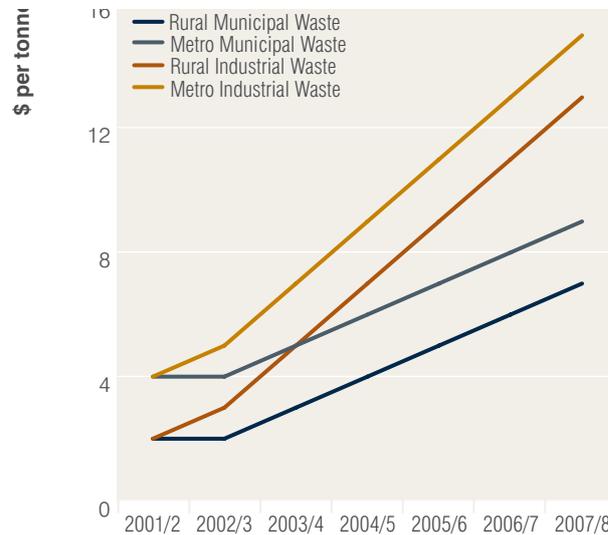
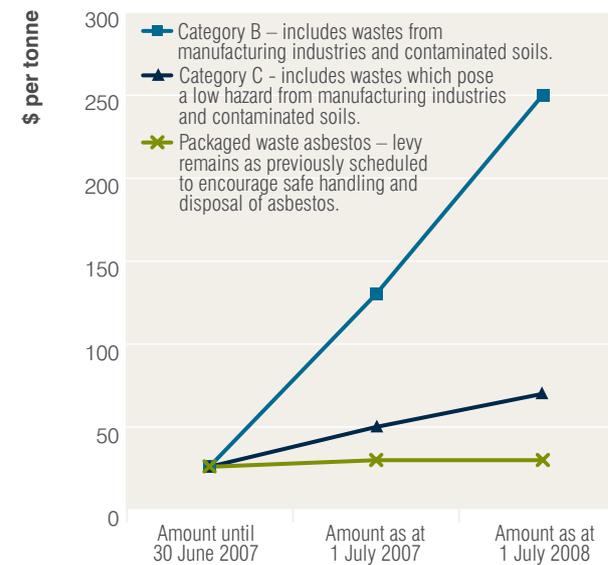


Figure M33 Hazardous waste disposal levy increases 2001–2008

Data source: EPA



Response Name

Towards Zero Waste

Responsible Authority

Sustainability Victoria

Response Type

Program

Target 4 - A 25% improvement, from 2003 levels, in littering behaviours by 2014.

This Towards Zero Waste target goes beyond focusing on consumer-generated litter, utilising the National Packaging Covenant to assist product manufacturers to reduce the potential for litter by way of better design. Progress towards the target is also being tracked via the use of improved litter measurement and reporting tools.

Evaluation of management responses

Initiatives that extend the responsibility of increasing the resource efficiency of materials beyond the 'waste' segment of the economy and back to consumers and producers are integral to reducing the environmental impact of material flows. Victoria has initiated some progressive programs in these areas as well as in waste management. However, there is scope for a greater range of products to be subject to both extended producer responsibility – for example, via take-back levies; and extended consumer responsibility – for example, via more comprehensive eco-labelling of a wider range of products. There is also greater scope for increasing the rational pricing of waste, which itself would create incentives for extended producer responsibility.

Currently, the responses listed above focus predominantly on increasing materials efficiencies in the production, manufacturing and waste segments of the economy (see Figure M34), with

stronger emphasis on manufacturing and waste than on other segments. Such initiatives are essential to reducing the environmental impacts of materials. Victoria, including through government agencies such as Sustainability Victoria and the Environment Protection Authority, leads the world in several areas.

Nevertheless, scope remains to further increase materials efficiency through such incentives. Some of these opportunities are highlighted above, and detailed below in the summary of recommendations.

Furthermore, conspicuous by their absence are any government responses that apply demand management to material flows, for example, to the consumption segment of the value chain. The consumption phase is the segment that is the predominant driver of the demand for energy, water and materials. It is also the stage of the economy in which the majority of the value invested into items is utilised (see Figure M5). Unlike the consumption stages of water and energy systems, where the government and community support demand management (for example the Save Water and Black Balloons campaigns), materials consumption is still seen as largely sovereign and is unchallenged. This is seen as a major gap in addressing the environmental impacts of material flows.

Recommendation

M7 The Victorian Government consider the establishment of pilot programs targeted to reduce material consumption for key, high impact consumables via demand management programs such as those that have already been initiated for energy and water.

For further information

Our Environment, Our Future
<http://www.dse.vic.gov.au/ourevironment-ourfuture/>

EPAs waste management actions
<http://www.epa.vic.gov.au/waste/default.asp>

Towards Zero Waste
<http://www.sustainability.vic.gov.au/www/html/1344-towards-zero-waste.asp>

Figure M34 Summary of government responses to material flows and their impacts (simplified)

Note: Green lines represent relative influence

