Plastics

A material of innovation for the electrical and electronic industry

Insight into consumption and recovery in Western Europe 2000

APME
ASSOCIATION OF PLASTICS MANUFACTURERS IN EUROPE
In recent years, plastics have become key to innovation in the electrical and electronic (E&E) industry - developments that are changing our lives and providing the technology to support us in a changing world.

The domestic and business worlds have been revolutionised by sophisticated electronics: more and more people across the world now have greater access to information and education thanks to computers, mobile phones, CDs and televisions. In the home, we have the convenience of washing machines, dishwashers and many other labour-saving kitchen devices and electric tools.

Plastics are increasingly the material of choice in this sector. In 1980, on average, plastics made up 15 per cent by weight of all E&E equipment. By 2000, this had risen to 20 per cent. Designers specify plastics because of their performance benefits and efficient use of resources: weight reduction, miniaturisation, electrical and thermal insulation. Advanced features such as high-density data storage systems require plastics materials during the processing and application phase. The progress of the information age has been made possible by the versatility of plastics, developed to meet specific needs.

In 2000, 13 574 000 tonnes of electrical and electronic goods, including cables and electrical equipment produced in Western Europe, an annual increase of 4.3 per cent since 1995. This included 2 670 000 tonnes of plastics. This is an important sector for the European economy, employing an estimated 2.2 million people.

Electrical and electronic goods are currently an area of particular focus because of the proposed European Directive on Waste from Electrical and Electronic Equipment (WEEE). The directive would cover the 6 713 000 tonnes of electrical and electronic goods produced in Europe in 2000. Unlike the 1995 APME report Plastics - a material of choice for the electrical and electronic industry, this report concentrates on those sectors covered by the proposed European WEEE Directive.

The use of plastics drives development of higher performance, more convenient and affordable electrical and electronic equipment. It also makes a valuable contribution in ensuring this development is sustainable, in environmental, social and economic terms: use of resources is minimised, wealth and jobs are created and improvements to society are the results of using plastics in the E&E sector.
innovative plastics solutions

Plastics' unique combinations of properties make them an indispensable material across the diverse range of electrical and electronic equipment - whatever their size, shape or application.

Innovation in this sector leads to constantly evolving product design. For small appliances like mobile phones, this has led to an increase in the use of plastics and the number of different polymer types used, as smaller integrated components are specified. In larger domestic appliances, the amount of plastics is also increasing, for example to improve insulation and reduce energy consumption for refrigerators.

Compared to other industries, the electrical and electronic sector uses a broader range of plastics in smaller volumes, with each plastic having a specific role to play. The chart on the right highlights this by quantifying different plastics used in two industry sectors: electrical and electronic packaging. Such a spread in plastics allows for high performance product innovation but does have implications for recovery at end of life.

The mobile phone is a perfect example of the complexity of small E&E appliances. Booming use of mobile telephones is fuelled by ever smaller, lighter handsets made possible in large part due to plastics. Since 1992, the average weight of a mobile phone has decreased from 500g to 100g in 2000. Plastics make up to 75 per cent by weight of a mobile telephone, compared to an average of around 50 per cent for small household appliances.

A complex variety of plastics and other materials is necessary to provide a lightweight, strong yet small device - which is safe and user-friendly. All the materials are integrated into tiny handsets, rather than being separate components. This produces a particularly complex waste stream, with a mix of small amounts of different plastics and other materials that are difficult to separate. Where mobile phone recycling schemes have worked in Europe, it has been through reclaiming the value of the precious metals they contain.

The mobile phone keeps Europe on the move

<table>
<thead>
<tr>
<th>Polymer</th>
<th>E&amp;E</th>
<th>Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>496</td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>287</td>
<td>PS 1 014</td>
</tr>
<tr>
<td>PP</td>
<td>266</td>
<td>PP 2 783</td>
</tr>
<tr>
<td>PU</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>EP</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>PVC</td>
<td>54</td>
<td>PVC 689</td>
</tr>
<tr>
<td>PC</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>UP</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>PA</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>POM</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>PET-PBT</td>
<td>19</td>
<td>PET-PBT 1 445</td>
</tr>
<tr>
<td>PE</td>
<td>8</td>
<td>PE 7 514</td>
</tr>
</tbody>
</table>

Notes: 1. Each sphere represents the relative amount of polymer used in the sector 2. Data does not include plastics used in cables and electrical equipment
Plastics consumption by the E&E sector was 2,670,000 tonnes in 2000, an increase of over 25 per cent since 1995.

Plastics in E&E equipment are highly visible, for instance in telephones, televisions and computers. However, there are also many plastics components, hidden from view, that provide the infrastructure to connect and support modern lives. Nearly half of all the plastics used in the E&E sector is used in sheathing for cables and electrical equipment. The unique electrical insulating properties of plastics and their strength, stress resistance, flexibility and durability make them the ideal material for safe and efficient power supply. If we consider the E&E equipment covered by the proposed European WEEE Directive, 1,483,000 tonnes of plastics were used in Western Europe in 2000.

Excluding cables and electrical equipment, three major sectors – large household appliances, IT/telecommunications, and consumer equipment – account for over 85 per cent of the plastics used in the E&E sector. On average, plastics account for almost 20 per cent by weight of electrical and electronic equipment.

### Total consumption in E&E sector, Western Europe 2000 (x 1,000 tonnes)

<table>
<thead>
<tr>
<th>Category</th>
<th>Plastic Consumption</th>
<th>Total Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>E&amp;E tools</td>
<td>11</td>
<td>97</td>
</tr>
<tr>
<td>Automatic dispensers</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td>Toys</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Medical equipment</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>Lighting equipment</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>Monitoring and control instruments</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>IT and telecommunications</td>
<td>595</td>
<td>2,279</td>
</tr>
<tr>
<td>Large household appliances</td>
<td>481</td>
<td>2,826</td>
</tr>
<tr>
<td>Consumer equipment</td>
<td>217</td>
<td>2,826</td>
</tr>
<tr>
<td>Small household appliances</td>
<td>151</td>
<td>312</td>
</tr>
<tr>
<td><strong>Total consumption for E&amp;E equipment</strong></td>
<td><strong>1,483</strong></td>
<td><strong>6,713</strong></td>
</tr>
<tr>
<td>Cables</td>
<td>995</td>
<td>3,969</td>
</tr>
<tr>
<td>Electrical equipment</td>
<td>192</td>
<td>2,882</td>
</tr>
<tr>
<td><strong>Total consumption in the E&amp;E sector</strong></td>
<td><strong>2,670</strong></td>
<td><strong>13,574</strong></td>
</tr>
</tbody>
</table>
The consumption of plastics in the E&E sector generally depends on the use of electrical and electronic equipment and demographics of each country. Germany, France, the UK and Italy are the largest consumers, as illustrated in the pie chart below, together accounting for almost 80 per cent of the plastics used in E&E equipment in Western Europe.

The broad range of plastics used in E&E equipment is needed to meet the different demands of a variety of appliances. Often individual pieces of equipment contain small quantities of many different plastics. Large household appliances are the exception. Here polypropylene (PP) and polyurethane (PU) insulation account for 57 per cent of plastics consumption. ABS is used extensively in the expanding IT and telecommunications sector for computer housings and telephone handsets. This sector accounts for 63 per cent of ABS consumption and the 72 per cent increase in consumption since 1995.

Total consumption of PVC in the E&E industry is 474 000 tonnes when including the PVC used in cables installed in buildings. The chart below right shows the polymers included in the proposed European WEEE Directive.

The main growth has been seen in the most innovative sectors driving forward economic growth in Europe. In 1995, data processing accounted for only five per cent of plastics consumption in the E&E sector, yet by 2000 it stands for 29 per cent. In the IT and telecommunications sector, consumption has increased from 337 000 tonnes in 1995 to 595 000 tonnes in 2000. This is not simply due to the rapid expansion of the sector – the amount of plastics used in IT and telecommunications equipment is also increasing, making up 26 per cent of the materials used in 2000, compared to 17 per cent in 1995. In 1995, large household appliances used the most plastics. Although this is still growing, by 2000 IT and telecommunications were using more plastic than any other E&E sector.
The past 20 years have seen spectacular development in the use of electrical and electronic equipment. This has meant increasing specification of plastics as the ideal material to meet the needs of the sector.

Forecasts indicate that plastics, with their ability to be made “fit for purpose”, will continue to grow faster than any other material in the E&E sector. Data from 1980 to 2000 show how plastics are clearly the material of choice for E&E goods, particularly in the most progressive sectors. While plastics consumption continues to grow across all sectors in the E&E industry, the greatest increase has been seen in IT and telecommunications, with plastics consumption overtaking that for large household appliances for the first time.

The unique properties of plastics have also enabled the development of innovative new products. CDs made from plastics regenerated the music industry, and enabled millions to enjoy better quality recordings of their favourite music. They also increased access to information and education, for example through encyclopedias published on CD-Roms. Laser systems for precise medical procedures rely on plastics parts and in the telecommunications industry, plastics tubing protects optical fibres allowing for fast transfer of large quantities of data.

Plastics - the material of choice
The metal tub that keeps washing machines waterproof is increasingly replaced by a moulded plastic tub which has the advantage of being lighter and more affordable and easily formed in the required complicated shapes.

Note: no detailed data for 1981-1991
Fire safety is an important consideration for all equipment either using or carrying electricity and generating heat. Plastics are derived from fossil fuels and, as a result retain some of their properties. In particular, plastics can ignite when exposed to a direct open flame.

In order to ensure the safety of certain E&E equipment, the plastics industry has developed plastics containing additives, known as flame retardants, to make them safer. Today there are two main types of flame retardants: brominated and non-brominated additives. The type of flame retardant used depends both on the type of plastics and on the safety standards that the equipment is required to meet. Consequently, there are a variety of different flame retardants used in plastics.

The European plastics industry has committed considerable resources to developing flame-retardant plastics that meet the high safety standards required for E&E equipment. There is a particular focus in this development on technical and environmental issues.

To ensure consumer safety, about 12 per cent of all plastics used in the E&E sector contain flame retardants, mainly television housings, computer monitors and cases. In office equipment connectors and printed circuit boards.

Recovery of components containing halogenated flame retardants:
The separate collection of plastics containing halogenated flame retardants would require total dismantling and separation of even extremely small components to isolate flame-retardant materials. In the light of increasing integration and miniaturisation technology, this is neither economically nor practically feasible.

Energy recovery is the most eco-efficient option to treat these components. This has been demonstrated through combustion trials with flame retardant E&E equipment in Germany by combining them with municipal waste.

APME has also supported work to use flame-retardant PC scrap and electronic circuit boards, which contain a high amount of recoverable precious metals, as fuel in metal smelters in Sweden. In this recovery process, plastics play a dual role, both as a reducing agent and as an energy source for the metal recovery.

### Case studies

#### The TAMARA project
APME has a comprehensive testing programme investigating the impact of plastics on municipal solid waste incineration. In 1997, APME conducted a study to evaluate the incineration of waste from electrical and electronic equipment at a municipal solid waste combustion pilot plant, TAMARA, at the Forschungszentrum Karlsruhe in Germany. The tests demonstrated that medium to high (3-12 per cent by weight) quantities of E&E waste containing brominated flame retardants can be safely added to today’s municipal solid waste to generate useful energy. The major conclusions of the study included:
- Clean gas emissions recorded, falling well within the lowest regulatory limits required by the German dioxin regulations
- Controlled municipal solid waste combustion is an effective ‘dioxin sink’, well within legal safety requirements
- E&E waste should be treated for efficient metal separation prior to combustion since the major portion of heavy metals in E&E waste is not due to plastics, but to poor metal separation
- Current European municipal solid waste combustion capacity will allow energy recovery of significant amounts of specified E&E plastics waste

#### The Bolden Project
Innovative approaches to recycling plastics are now used which have significant economic benefits in terms of reducing waste management costs. To produce copper from recycled material rather than from ore, means that only one-sixth of the energy is needed. Waste from the E&E sector can now be used as a feed stream in non-ferrous metal smelting plants.

Between 1995 and 1999, APME and the American Plastics Council (APC) joined forces with Bolden Minerals AB in Sweden to show that E&E equipment such as personal computers can be used in the same way that scrap cable and printed circuit boards have been used, as secondary raw materials. This waste from E&E equipment contains metals that can be extracted with the plastics providing energy in the smelting process. With emission levels remaining the same and safety standards met, 15 000 tons of personal computers’ scrap could be treated in the plant.
The European plastics industry is committed to responsible waste management with the primary aim of avoiding loss of this valuable resource to landfill. Waste from E&E equipment constitutes only a small fraction by weight of total waste in Europe - less than 0.2 per cent. Of this fraction, around 18 per cent comes from plastics. Plastics waste from the electrical and electronic sector accounted for around four per cent of total plastics waste in Western Europe in 2000.

IT and telecommunications and large household appliances account for 75 per cent of all plastics waste from the E&E sector.

The proposed European WEEE Directive sets out detailed and ambitious recovery and recycling targets for many types of electrical and electronic equipment described in this report. Waste recovery is an integral part of a product’s life cycle and waste management solutions should be primarily eco-efficient. Eco-efficient solutions provide the optimum balance of environmental impact and economic cost from initial production through to disposal at end-of-life. The diagrams show both all waste from the E&E sector in general and theoretical waste from only that E&E equipment covered by the WEEE Directive.
The plastics industry is keen to ensure that waste recovery continues to keep pace with plastics consumption. Plastics waste quantities from the E&E sector will increase to around 1 130 000 tonnes by 2005. The plastics industry is working towards developing sustainable solutions to deal with E&E products at the end of their lives.

To calculate projected waste, a theoretical model of the lifespan of E&E products is used. While most telephones and small domestic appliances are assumed to have a lifespan of between five and ten years, large domestic appliances are assumed to last for between ten and twenty years. Increasing use of modern, high-performance plastics also increases the durability of large domestic appliances.

The largest areas of plastics consumption – large household appliances and IT & Telecommunications – also produce the most waste. Concentrating recovery efforts on these areas will have the best potential for success.

Recycling commands much attention as an important waste management option and the industry is committed to the re-use and recycling of E&E products where environmentally and economically viable. However, for effective and economic recycling there is a need for clearly defined, high quality waste streams. Only large appliances such as copying machines or other office equipment, refrigerators, TV sets or computer monitors could provide the necessary plastics volumes for a potential recycling operation.

There is a useful body of experience about recycling such equipment to draw upon, whereas in faster developing sectors such as telecommunications there is a lack of experience.

Mechanical recycling is neither practical nor always the most environmentally responsible option for all E&E plastics. Plastics components can be very small and expensive to separate from other materials, making it difficult to create the homogenous waste streams necessary for environmentally and economically sound mechanical recycling. In such cases, energy recovery and feedstock recycling options are more viable alternatives.

Forecast of plastics waste from E&E equipment, Western Europe 1995-2005 (x 1 000 tonnes)

<table>
<thead>
<tr>
<th>Year</th>
<th>IT and telecommunications</th>
<th>Large household appliances</th>
<th>Consumer equipment</th>
<th>Small household appliances</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>145 (25%)</td>
<td>283 (49%)</td>
<td>75 (13%)</td>
<td>58 (10%)</td>
<td>17 (3%)</td>
</tr>
<tr>
<td>2000</td>
<td>264 (34%)</td>
<td>319 (41%)</td>
<td>109 (14%)</td>
<td>70 (9%)</td>
<td>16 (2%)</td>
</tr>
<tr>
<td>2005</td>
<td>474 (42%)</td>
<td>361 (32%)</td>
<td>158 (14%)</td>
<td>113 (10%)</td>
<td>23 (2%)</td>
</tr>
</tbody>
</table>
The European plastics industry promotes the adoption of a flexible approach to plastics waste management, encompassing an optimal balance of technical, environmental, economic and local market factors, ensuring that natural resources are used efficiently.

The integrated and minimised nature of E&E products, with many small components combining plastics, metals and glass, can make them difficult to handle in some waste management options. However, a number of options do exist to recover plastics-based electrical and electronic waste. The industry believes the best way forward is to aim for eco-efficient recovery by using the best combination of recovery options, subject to specific circumstances.

Mechanical Recycling
As we have seen, E&E equipment uses many different types of plastics, designed with special properties for producing high-specified products as efficiently as possible. To mechanically recycle post-user plastics waste, it has to be collected, sorted, separated, ground, washed and reprocessed before it can be mixed with virgin plastics of the same type for moulding new products, or used on its own for alternative lower value products, provided a market exists. The availability of consistent waste streams with known characteristics is thus a key criteria for successful recycling. Only in a limited number of cases is the overall plastics recycling operation economically viable because of the relatively low cost of new, virgin plastics. In terms of environmental impact, it is also important to ensure that the resources used in the recycling, including energy and transportation, do not exceed the environmental benefits of recycling the product.

In 1999, 26 000 tonnes of plastics from the E&E sector were recovered using mechanical recycling. This came mainly from large domestic appliances such as refrigerators or from computer housings, which contain a significant quantity of one type of plastic to provide a consistent waste stream. Practical experience shows that for material recycling to be viable, there must be homogenous plastics and a large constant waste stream. The markets for recycled plastics are limited due to technical feasibility and economics. Small impurities from different plastics or other materials can easily occur during the recycling processes and drastically decrease the electrical and mechanical performance or safety of recycled plastics. Virgin plastics are usually cheaper and always of higher quality than recycled plastics.

Feedstock Recycling
While, in principle, feedstock recycling has great potential to boost plastics waste recovery levels, in practice, economic considerations as well as the availability of a constant quality and quantity of plastics waste are key to its viability. This depends heavily on the local situation. A variant of feedstock recycling, described in the Bolden case study on page 6, is the use of plastics as a chemical reductant necessary for the recovery of non-ferrous metals. Here the plastics not only react with the metals, but are also used for their energy value.

Energy Recovery
Energy recovery is a key recovery option for plastics, as their basic raw material, is derived from oil. While in the past, there has been much opposition – some justified by concerns around the poor environmental performance of old incinerators – today energy recovery is more widely required as an environmentally sound option. Emission levels from incinerators have been significantly reduced and waste combustion for the recovery of energy is embodied in European legislation. For appliances that are not appropriate for mechanical recycling – e.g. small appliances with many small parts – energy recovery is the preferred route of waste recovery. This involves the generation of energy through incineration with the recovery of heat, sparing other finite fossil fuel resources such as coal and oil. As well as municipal incineration with energy recovery, potential also exists as an alternative fuel in other processes.

Energy recovery, alongside material recycling, has a vital role to play in diverting plastics waste from landfill and maximising environmental gain. The results of an APME study into the eco-efficiency of plastics packaging waste recovery, indicate that, when combined with energy recovery, raising recycling rates from 15 to 50 per cent increases costs by a factor of three, while environmental benefit remains broadly similar. While this research focused on the packaging sector, APME has commissioned a study on the eco-efficiency of three E&E applications: a television, a mobile phone and a refrigerator.

Re-use
The rapid pace of product development and innovation means latest models replace older models, leading to shorter and shorter lifespans for innovative sectors such as IT and telecommunications. Although specific parts can sometimes find re-use possibilities, in general such rapid developments usually means re-use is not feasible.
Everyone is increasingly aware of the need to act more responsibly to protect our world for future generations. This is crystallised in the drive for ‘sustainable development’ - acting in a way that does not limit the range of economic, social and environmental options available. Plastics use in E&E equipment is enabling the sector to play an increasingly important role in achieving this goal and helping to improve the overall standards of living of a growing world population in a cost-effective, resource-efficient manner.

Environmental Protection
Plastics in E&E help save resources such as oil, or other fossil fuels. Plastics in all industries consume only a small fraction – four per cent – of the world’s oil as feedstock. This fraction is used so effectively that fossil fuel reserves last longer as a result. In fact, it is estimated that the use of plastics overall saves more oil than is needed for their manufacture. Plastics use less to do more because they are lightweight and specially tailored to the demands of the application. As a result, waste is minimised. The plastics industry is committed to applying both established and innovative polymer technologies to conserve resources and reduce atmospheric CO₂ – the key environmental challenges.

Household energy consumption decreased by design developments

Innovations in the design of household products in recent years have improved their insulation, performance and hence, energy efficiency.

- By increasing the amount of plastics foam insulation by 15mm over the lifetime of the refrigerator, 17 times as much energy is saved as used in the manufacture of the foam.
- The best products today consume about half as much energy and water as typical ten-year-old products.
- UK households spend 1.9 billion euro each year on electricity to run fridges and freezers - nearly as much as the power needed for all the offices in the UK.
- An average German family would reduce their energy consumption by 1000kWh, water use by 22 500 litres, carbon dioxide emissions by 600kg and save 245 euro in one year if they replaced their ten-year-old refrigerator, freezer, washing machine and dishwasher with new, efficient ones.

The whole lifecycle of the appliance has to be considered when evaluating the environmental impact of recycling and recovery because, for example, most of the refrigerator’s environmental impact is as a result of its energy consumption during use.

A unique combination of properties has placed plastics at the centre of materials developments in this fast-evolving sector. For this reason, the plastics industry will continue to provide information and is open to working with legislators, businesses and environmentalists alike to determine the optimal solutions for waste management. Only by demonstrating its commitment to sustainability the industry can ensure that plastics remain the material of choice for the 21st century.

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Plastics enable us to build smaller computers and mobile phones using less resources in production and over their lifetime.

- Increased plastics insulation in refrigerators saves fossil fuels through reduced energy consumption.
- Plastics are integral to the design and construction of alternative, renewable energy sources through solar panels and wind turbines and in this way also help to extend the life of our fossil fuel reserves.

Economic Development
The plastics industry adds value to society through the significant employment and wealth it creates. The wider plastics industry in Western Europe employs over one million people and plastics consumption consistently outpaces national GDP throughout the world.

- In the electrical and electronic sector and related fields it is estimated that 2.2 million people are employed.
- An innovative E&E industry keeps Europe at the forefront of the global economy and empowers the 21st century’s knowledge workers.

Social Progress
Plastics in modern technologies and medicine provide access to higher standards of living: enhanced health and longevity, safety, communication and leisure time for an ever growing proportion of the world’s population.

- In healthcare, complex electrical equipment is critical to life-enhancing and life-saving surgery. Plastics are hygienic, easily cleaned and durable. Lightweight and hard-wearing plastics have allowed portable equipment to be developed for emergency situations.
- Cables sheathed in plastics are the physical links that make the Internet, E-commerce and today’s communication economy possible.
- Modern domestic appliances have reduced the time and effort needed for routine housework, freeing time for work or leisure activities.
- E&E equipment provides educational possibilities and communications to remote regions; it enhances safety provision in many situations, for example, monitoring air traffic to reduce accidents.

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The Association of Plastics Manufacturers in Europe (APME) is the voice of the polymer producing industry at the European level. Its membership today includes more than 40 companies representing well over 90 per cent of Western Europe’s polymer production, with a turnover of more than 29 billion euro. Combined with the European polymer converting industry and the machinery manufacturers, the plastics industry represents a major contributor to Europe’s economic strength employing well over one million people and generating sales in excess of 135 billion euro.