# Plastic bags – a hazard for the environment and a challenge for contemporary engineering educators

**Beata M. Macur† & Zenon J. Pudlowski‡**

World Institute for Engineering and Technology Education, Melbourne, Australia†
World Institute for Engineering and Technology Education, Melbourne & Monash University, Melbourne; Australia‡

ABSTRACT: In the 1970s, a commercial system for manufacturing plastic grocery bags became operational and the first grocery plastic bag, made of light High-Density Polyethylene (HDPE) film, was introduced to the supermarket industry as an alternative to paper sacks. Plastic bags became very popular with consumers and retailers, as they are a hygienic, lightweight and strong form of packaging. On the other hand, plastic bags have become a real hazard to the environment because they do not break down in landfills for a very long time and, even more critical, if left in the environment and washed down to the sea, they are swallowed by marine life that mistake them for food. In recent years, governments in many countries have started to work with industrial engineers and environmentalists to reduce the environmental impact of plastic bags. The question to ask is whether plastic bags really represent an environmental hazard and is recycling the only solution for waste plastic bags? In this article, the authors endeavour to analyse the history of plastic bags by looking at why they have become a problem and what potential future solutions are.

## INTRODUCTION

Packaging is an inseparable component of a product and plays an important part in today's competitive marketplace, where producers are racing to satisfy often-conflicting demands such as *quality/quantity balance*, how to lower costs and how to enhance the environment attributes of their product.

These conditions are not easy to fulfil and this is why plastic film's appearance in the market place has allowed manufacturers to meet marketplace demand by enabling them *to do more with less*. This is the reason why plastic bags appeared in the marketplace across the globe. One crucial aspect of using enormous amounts of plastic bags seems to be forgotten – its afterlife, starting from the moment it becomes a waste product. Obviously, the impact of the plastic bag on the natural environment has become very costly.

From the waste management point of view, the plastic bag is generally perceived as one of the main litter items, with cigarettes butts having the highest ranking. It is a burden for landfill because commercial and domestic waste is full of plastic film.

Engineers were indispensable in the process of inventing and mastering plastic film packaging and now they are being asked how it can be made to disappear or to break down and be safe for the environment. Therefore, a holistic approach to the plastic bag problem is needed to determine a solution for its usefulness in the future.

## HISTORICAL BACKGROUND

One of the definitions of a plastic bag is as follows:

> *A plastic bag or pouch is a type of flexible packaging made of thin, flexible plastic film. Plastic bags are used for containing and transporting foods, powders, ice, chemicals, waste, etc* [1].

The first plastic bags were introduced in the 1970s as food packaging in the USA, later they were used as waste/trash bags or bin bags. The first plastic bags started to be manufactured on a commercial scale in 1973. In 1977, the plastic grocery bag was introduced to the supermarket industry as an alternative to paper sacks [2].

In the 1980s, markets experienced an explosion in the number of plastic bags available at supermarkets. Supermarkets begin to say: *paper or plastic*. In the 1990s, consumer distaste and disapproval of the environmental impact of plastic bags started to grow. As a result, in 1994, Denmark introduced the first plastic bag tax. It is interesting that a cheap and

convenient form of plastic film packaging has become very costly to the environment, because plastic bags can take between 400 to 1,000 years to break down and their constituent chemicals remain in the environment long after that [2].

Usually, a plastic bag is made of high-density polyethylene (HDPE) derived from crude oil. It is stated that *It takes 1.75 kilograms of petroleum (in terms of energy and raw materials) to make one kilogram of HDPE* [1].

Plastic bags became an obvious hazard for the environment in terms of their threat to wildlife, especially when disposed of inappropriately. This also means an additional cost for society and future generations. Hence, this situation can be mentioned as another example of an engineering invention used by the market economy for profit only, without thinking of the afterlife of the product, which is the cause of the waste problem today.

AUSTRALIA

It is acknowledged that 20 million Australians use 6.7 billion plastic check-out bags every year. The reason that so few people can use so much plastic says a lot about the wasteful habits of today's Australians; this constitutes the use of nearly one plastic bag per person per day. At least 80 million plastic bags end up as litter on our beaches, streets and parks. Australian Local and State Governments spend over $200 million a year on picking up litter [3]. It has been also pointed out that …*For some time now, the grave environmental problems caused by plastic shopping bags have received attention in Australia* [4].

Australia is ranked as one of the top countries for its high awareness of the environment and nature issues by members of its society but unfortunately it is facing the same waste issues (i.e. the plastic bag problem) as other western countries, because about 4 billion HDPE plastic bags are imported every year. One attempt to reduce the impact of plastic bags on the environment since 2002 has been when the *Federal Government and the Australian Retailers Association (ARA) … agreed to cut plastic check-out bag usage by 25 per cent by the end of 2004, rising to 50 per cent a year later. Environment Ministers support the total phasing out of light single use plastic bags within five years* [3].

Actually, in many supermarkets and other retailers calico bags are available at very low cost (about $1 each) as a replacement for plastic bags. Many towns undertook the challenge supported by Planetark or Ecorecycle/Sustainability Victoria to become a *Plastic Bag Free Town*, whereby no shops in a town would allow plastic bags to be offered. However, fewer than 3% of Australia's plastic bags are currently being recycled, despite recycling facilities being available at major supermarkets. In many council areas, plastic bags are the single main contaminant of kerbside recycling. Some local councils employ staff whose sole job is to collect bags that might end up as litter flying out of landfill [3].

A simple conclusion can be drawn here that the plastic bag problem could have been avoided in Australia, because there was no need for the Australian market to follow other western countries' mistakes.

EUROPE

Generally, European countries started dealing with the plastic bag problem earlier than Australia, as early as the 1980s. There are already solutions to this problem in countries within the European Union.

As with many other waste management issues, the plastic bag problem is not alone to be somehow regulated by governments. Levies and taxes seem to be the simplest and most powerful tools available to governments in order to execute equity for buyers and producers of plastic bags.

For example, a tax on plastic shopping bags in the Republic of Ireland, introduced as one of the first in Europe in 2002, has cut their use by more than 90%. A charge of 0.15 € per bag resulted in the reduction of 1.1 billion plastic bags used and added millions of Euros into revenue. Shoppers are being encouraged to use calico reusable bags, which has also evidently raised the environmental awareness throughout the nation [7].

After Ireland's success in introducing the plastic bag levy other European countries are likely to follow. France and Belgium are already encouraging reusable or biodegradable bags. England is keen to introduce a plastic bag levy, and Italy started to be *sick of* the plastic bag epidemic. In Germany, retailers do not supply any packaging in grocery stores unless the buyer pays for it.

To justify the governmental tax on plastic bags in Europe, it is worth highlighting that the recycling of plastic bags is not efficient economically or environmentally. Many European countries have already tried to encourage people to recycle plastic bags, but very few customers returned them to shops for reprocessing. It is simple: when one pays for something, one values it.

However, while the levy on plastic bags is helping to reduce the use of plastic bags, the issue of cutting their use is crucial and this is being currently introduced throughout European countries. Unfortunately, these processes are happening much slower in those countries that have recently joined the EU.

## PLASTIC BAG PROBLEMS IN OTHER DEVELOPPED AND UNDER-DEVELOPPED COUNTRIES

It is generally known that waste disposal standards are set in developed countries but the situation in developing countries is entirely different. Most of the developing countries do not have waste management standards or are trying to adopt them from developed countries, which are not always suitable and appropriate to their situation.

The plastic bags' case is one whereby developed countries do not always lead by example, especially in the environmental protection field. It is stated that:

> *Countries from Taiwan to Uganda, and cities including Dhaka in Bangladesh, have either banned plastic bags out-right or imposed a levy on consumers. But critics say the US is years behind countries in Europe, Asia and Africa,* [where] *plastic bags are favoured because they are cheap and durable* [5].

The excessive number of plastic bags being used in the USA is worrying because the raw material for their production is very costly, and it is an American myth that they are free. About 12 million barrels of oil are used to make the bags consumed in the USA each year [5]. In addition, from the waste management point of view, a lifecycle of a product has to be considered from raw material to its safe disposal. So far, none of this information concerning plastic bags is passed on to the American consumer, whose opinion is cited here: *plastic bags come from plastic bag land* and further …*We don't think about where they come from and where they are going* [5].

Other countries such as Pakistan and India are on the way to increasing awareness of the issue and setting up measures to control plastic bag use because they became a real problem if mixed with other human, animal and industrial residues. Hong Kong is conducting a study on the shopping bag levy in order to reduce its environmental impact. Japan is also undertaking actions to reduce plastic bag use, such as stickers for paid items instead of packing them in polyethylene bags, and is also close to introducing a plastic bag levy [8].

## WHY HAS THE CHALLENGE OCCURED?

The plastic bag problem has grown up fairly rapidly from being only a waste problem on the municipal level to a global health and life threatening issue, which can be characterised in the following points:

- Plastic bags are a real hazard for the environment and especially today when they are in mass production – between four to five trillion is produced globally each year – there is no universal regulation about their disposal and their afterlife threat to the natural environment;
- If they end up as litter in waterways and clog drains of storm water, it poses a direct threat to storm water systems. For example, in India, during last monsoon rains they choked drainage systems, which brought additional loss of life, and losses to the economy [8];
- Lots of rubbish with plastic bag content is floating across oceans (i.e. creating the *Great Pacific Garbage Patch, where millions of tonnes of garbage – from plastic bags to footballs, buckets and fishing nets – has gathered over the past 50 years*). It goes on to say that …*It is almost like plastic soup. It is endless for an area that is maybe twice the size of the continental United States* [9].

This *plastic soup* around the globe is about to spill over to make the whole of humanity face this problem. One hopes that it will be dealt with appropriately before it is too late.

It is evident that the plastic bag, once an innovative product, became very dangerous and difficult to deal with on a global scale. What will be the solution for the future of plastic bags? It is difficult to answer this question because of its complex nature. This problem has occurred because the major tool for driving sustainable production and consumption of plastic bags, which is a Life Cycle Analysis (LCA) of a product, was neglected. It is highly possible that the plastic bag afterlife at the beginning was not so important simply because its production quantity was low. Unfortunately, a lack of monitoring and proper care in this matter has brought us all to today's situation. It should also be stated that plastic bag litter is considered an environmental crime and, as such, has become a legal issue. There is no point of finding out who is responsible for the plastic bag problem today, because we are all concerned about it. However, it is necessary to point out the responsibilities for the problem and to identify those responsible for its solution.

## THE ROLE OF ENGINEERS AND EDUCATORS IN THE FUTURE

It is evident that a consolidated effort is needed to target the plastic bag problem in order to save our environment, not only for ourselves but also for future generations. It is a great challenge for engineers and engineering educators to search for solutions and to break down the conspiracy of silence on plastic bags over their consumption and inappropriate disposal around the world. In addition, a well-constructed education programme for the general public is needed. Taking only public education and levy mechanisms into consideration, is obviously not enough to stop the *appetite* for plastic bags. A plastic bag levy creates complications rather than solutions to this problem, because the

consumer has already paid for the bags, and to dispose them may not be the best option for the consumer. Blaming and targeting plastic bag manufacturers and big retailers is not a viable solution as the problem is much more complex.

As stated in the *Innovations in Engineering Education, Curriculum, and Infrastructure* (IEECI) program, which supports research in engineering education, one of the pillars of its programme is the *integration of sustainability into engineering education.* It also states that:

> *Engineering leadership education is emerging as a topic in engineering institutions worldwide. But the review of international* best practices *in engineering leadership education says a lack of resources, expertise, and formal networks in the nascent field is causing concern in a professional threatened by a diminishing focus on the notion of the* engineer-as-doer [10].

Engineers need to become the ones involved in generating and proposing solutions for the plastic bag problem around the world as they have the best knowledge of the product coming from the extraction of the raw materials through to processing, transport, use, re-use and recycling.

Engineering curricula should include mechanisms on how best to apply research into the world trade market. It would be appropriate and, indeed desirable, if engineers were given, at the very beginning of their course, suitable training on how to perform best throughout their study and, what is even more important, on how to perform in the new world market at the same time contributing to their advancement in science and technology.

This scientific knowledge should form the basis for governments around the world in their search for a programme of solutions to the plastic bag problem. Surely, engineers and educators should be the key partners in such a programme.

## TASKS FOR ENGINEERING EDUCATORS

The market economy has made use of the engineering discovery of HDPE film and fabricated plastic bags but has never asked the question: *what is on the other side of the pipe?* That is, where plastic bags end up as waste.

As mentioned before, Life Cycle Analysis (LCA) was neglected and now all of humanity has to pay the price, as there is a global invasion of plastic bags without clear indications for the solution of this problem. Rethinking this product design is crucial for change to occur. This requires the rethinking of the use of the resources and materials for efficiency and for a reduced environmental impact, in order to improve living standards.

One of the possible solutions to the plastic bag problem is an engineered invention of biodegradable plastic film, which decomposes when exposed to air, water or sunlight. Such bags, when decomposing, consuming oxygen and release chemical residues, which is not desirable, especially when they end up in waterways.

The process of breakdown of a plastic biodegradable bag is much quicker than a regular plastic bag, but this strategy does not address the consumption part of the problem, because people might very quickly start to overuse them.

The illusion that plastic bags are free has to be publicly denied, because neither biodegradable nor old plastic bags are free. The combined cost of raw materials, including energy consumed during the production process and the pollution of the environment can not be neglected. The consumer pays for them through higher prices of purchased products and will have to pay for their disposal. This is unjust to the average consumer to be charged for an item that they never asked for. It has been pointed out that:

> *One major current trend in engineering leadership education is the development of the student's global awareness and their ability to work on complex cross-national projects – which is seen by many as the environment within which the engineering leader of the future will need to operate*…[10].

Therefore, it is hoped that as stated further …*The trend towards a more* global *view of leadership education …would continue* [10].

In order to improve future engineering communication across the industry, it would be appropriate if the consulting engineering body joined forces with engineering educators in devising and developing modern and relevant engineering education curricula. This opinion is based on many examples of waste companies and local governments employing specialised engineering firms to advise and cooperate with technical universities on issues and matters related to waste management and curricula development.

Engineering educators could be helpful in creating a future for plastic bags, by putting science to work by creating sustainable solutions essential for a better, safer and healthier life for people everywhere. Certainly, engineering educators, cooperating with sociologists observing people's behaviour, would bring innovative and enriched solutions to the global plastic bag dilemma.

Governments around the world should become involved in, and support, educational programmes seeking a solution for the plastic bag problem. As such they should promote such programmes by encouraging engineering educators to urgently introduce and implement topics and issues into engineering education curricula that relate to plastic bags' economic, environmental and social impact.

## CONCLUSIONS

The market economy should never neglect engineers and engineering educators in particular, as engineers create wealth and progress, and engineering education facilitates these processes. This may be particularly visible when considering the effects of the plastic bag problem, where the roles of engineering and engineering education have so far been grossly underestimated and undervalued.

Action to reduce the use of plastic bags is a critical element of a sustainable future. It seems that little progress has been made in this area, because none of the proposed solutions are universal. Also, the belief that recycling can fix the plastic bag problem is wrong. The recycling rate is still very low and plastic used for bags is of a low quality. Using paper grocery bags as an alternative is not the desired solution either, because their production is linked to cutting down trees, their recycling is costly and all exacerbate global warming.

Huge numbers of plastic bags are shipped from western countries to developing countries for their disposal. However, they do not disappear immediately and will pollute the local environment while they take hundreds of years to break down.

It seems apparent that collective efforts should be made to find a universal solution to the problem of plastic bags but, in the meantime, the use of the reusable calico bag should be encouraged and promoted as it seems to be the quickest and simplest way of alleviating this critical situation.

Influence groups, specialised organisations, local communities and governments, should encourage engineers and scientists to conduct research on the plastic bag problem in order to determine the best solutions, which may lead to entirely new inventions. For example, a user-friendly product could be combined with our cars, which seems to be another necessary tool for shopping. A built-in, detachable shopping basket would certainly revolutionise contemporary shopping habits.

Further, a comprehensive education system should be developed and introduced, where curricula include issues and topics concerning the plastic bag problem, in order to educate the population about this critical matter.

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