Dr William B. Gara BSc Hons, PhD, CChem, FRACI
[redacted]

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SUBMISSION TO THE 'INQUIRY INTO AUSTRALIA'S WASTE MANAGEMENT AND RECYCLING INDUSTRIES'

INTRODUCTION

I would like to make these remarks as a Materials Scientist who graduated with a PhD in Organic Chemistry about 48 years ago and after spending 7 years in academic research in the United Kingdom, I worked 9 years as Development Scientist in the Polyethylene manufacturing industry in Australia (that company is now a part of Qenos) followed by 7 years as Head of Materials Science at *Van Leer Packaging Worldwide Research and Development Division* in the Netherlands. Recycling was a very important brief for my Department and we had very substantial research grants for our recycling project from the Netherlands Environment Ministry. Subsequently I worked for 17 years until my retirement in 2012 as Manager of the Technical (and later also Data) Section of the Waste Management Branch of the NSW EPA.

Some time ago I watched with great interest the *60 Minutes* program about Australia's recycling efforts and how some of our plastics waste end-up in overseas countries where they are not processed responsibly. I appreciate that some of the claims made in the program were not representing accurately what Australia endeavours to achieve in recycling.

I am concerned, however, that Governments in Australia will rush-in to promote, probably with financial support, the establishment of a local plastics recycling industry without proper consideration of whether such an industry would be economically and environmentally sustainable, profitable and beneficial to society in the longer term.

The main point is that packaging, an in particular food packaging consumes by far the greatest tonnage of plastics in Australia. When mixed plastics collected kerbside are recycled by hot processing as plastics, a very low performance material is produced for which there is only a much smaller tonnage market available. This wasn't a problem for the quantity of Australian plastic packaging waste exported to China where the potential market for low quality reprocessed mixed plastics products is much higher, but even they didn't believe that this activity was worthwhile any longer.

No decisions should be made without serious consideration of the quality of the likely product, the applications and the size of the markets available for such products, as well as the financial sustainability of such a new industry without long-term government subsidies. I will justify these comments below. The mistakes made in NSW by encouraging the establishment of *Alternate Waste Technology (AWT)* facilities, which produce contaminated organic materials unsuitable for application to land, should not be repeated with the management of surplus plastics materials.

There are great challenges to the economically viable recycling of plastics. I believe that our current problem is that quite a long time ago we, or rather petrochemical giants such as ExxonMobil, chose the cheapest materials for our packaging of foods and other goods without thinking about how we can recycle/recover those materials in a closed-loop after the useful life of the products made from them is ended. Even though, it will not be a short-term solution, there is a need to reassess the types

of plastics materials which we should use in the long-term, especially for packaging. I have addressed this issue in the Addendum.

It is very important to note that Society has limited funds which it can afford to allocate to get the best outcomes for our environment, therefore, we need to evaluate and compare every endeavour with other environmental projects in order to get the 'most bang for those precious bucks'.

My contribution below is purely governed by knowledge of the science and technology related to materials and recovery processes. I also fervently believe in the need to conserve our non-renewable resources and also in their recycling – as long as they can be done economically without long-term subsidies from the public purse. I have retired, I am not working for any company and have no financial interest in any company involved with the recovery of energy from waste.

DISCUSSION

I recently looked at the Qenos website and noted that they have about 60 different polyethylene resin products (HDPE, LLDPE and LDPE) manufactured in Australia for the local industrial processes which turn them into various end-products. From my time in the development of different polyethylene resins, I know that each and every one of these resins has significantly different physical and chemical properties to suit not only the widely varying manufacturing processes that they are used in, but also the many very different customer requirements in the manufactured end products. For example disposable thin-walled plastics containers for takeaway food require resins which flow very readily in the high-speed injection-moulding process used in their manufacture and are therefore of low molecular weight (the polymer chains are relatively short), whereas the resin used for the manufacture of bottles for packaging detergents is very different because it not only needs to be resistant to stress-cracking caused by the chemical contents, but also needs to be of significantly higher molecular weight (much longer polymer chains) to be able to be processed by blow-moulding. The resin used for milk packaging is different again because of the important need not to impart a taint to the taste of the contents. The resins used for pressure pipes are of much higher molecular weight again in order to withstand the operating pressures for a long time.

The issue is that when we collect the discarded material kerbside and in other ways, not only are the many different types of polyethylene (HDPE, LLDPE and LDPE) mixed, but they are co-mingled with articles made from other thermoplastics such as PP, PVC, PS, PET, PC, as well as contaminants which are extremely difficult/costly to separate. In China they hand-separated the various plastics to the best of their ability, and in spite of that the Chinese decided that the material as presented was not worth recovering anyway, so it definitely won't be worthwhile in Australia either. Luckily the Container Deposit Scheme in some of the states presents specific containers only which as unique single materials are much easier to recycle economically, for example PET soft-drink bottles which are very readily recycled into new soft-drink bottles (closed-loop). The recycling of aluminium also consumes a lot less energy (about 10%) than its original production from aluminium oxide. It should be noted that if the containers are taken by the individual by car to the recycling point, more non-renewable hydrocarbon resources will be consumed in the form of fuel than the material to be recycled which also uses a lot of energy from non-renewable resources.

As noted above, the most important issue standing in the way of recycling (closing the loop) is that packaging, and in particular food and drink packaging uses a very high proportion of the plastics used in Australia. Apart from reusing the PET from soft-drink bottles, it would be difficult to recycle other materials in a closed-loop because of the very strict food-contact standards applicable to the packaging of foods and drinks.

It is true that one can recycle a small percentage of plastics collected into certain low-performance applications, and one should salute such companies as *Plastic Forests* in Australia, however this will only use a very small portion of what is collected kerbside, because the market for such low-performance products is small. I believe that it would be bad policy for Governments to stimulate investment in such plastics recycling activities by means of programs involving financial subsidies, so we need to look into what else we could do as a society. The Waste/Recycling Industry will selfishly promote recycling because they will make a profit as a result of the subsidies they receive from society. Apart from anything else, a lot of energy from non-renewable resources is expanded in some of the materials recovery processes, which may actually result in a negative net end-result for the environment.

The useful 'recycling processes' that spring to mind are the industrial processes which are able to break-down mixed plastics into diesel fuels in thermal processes, in which the energy required is obtained by using only a small percentage of the fuel produced, so that no outside energy is required. It would be far better for the Government in conjunction with the Waste Management and Resource Recovery Association (WMRR) to investigate and encourage the development/establishment of such processes, which would then reduce the amount of crude oil extracted to make fuels. This would be my choice as far as sustainability is concerned. This possibility must be seriously explored by an expert technical group before finalising any Government Policy on recycling. Let's not repeat the folly of encouraging AWM which produces a contaminated organic waste at great cost. Governments must also recognise in their *Waste Management Hierarchy* that energy recovery can be a higher value recycling process than the making of low performance materials (at a financial loss) by material recycling.

The other process, which is a bit more contentious, is the well-established process of recovering energy by combustion of plastics combined with other wastes collected kerbside for which there are no better options – for example the NSW EPA/Government recently withdrew permission to apply to land so-called compost manufactured from mixed municipal wastes, because of the unacceptable levels of contamination present in such organic products. It is well documented that there are a number of commercially available and proven energy recovery processes (by means of combustion) which have exhaust gas clean-up processes (and safeguards which shut the process off if there is a malfunction before any pollutants are emitted) which ensure that what is emitted is cleaner than the exhaust gases out of our cars and trucks. In any case even a possible momentary emission of any contaminants is not a health issue because they are not only **not** *acute toxicants* but they are also vastly diluted in the atmosphere to insignificantly low levels. The only way old style incinerators presented a potential health problem was that people living nearby were subjected to these *chronic* and other types *non-acute toxicants* on a *day-in-day-out* continuous exposure for many years which in a few cases may have resulted in negative health impacts. Chlorinated dioxins and furans are no longer a problem either in properly designed/managed energy recovery processes, but there are organisations/people who are very active in trying to scare the general public and therefore Governments from permitting, let alone encouraging the establishment of such energy recovery processes. Something needs to be done to counteract this baseless scare-campaign against thermal energy recovery processes which are perfectly safe from negative environmental and health impacts these days, and are beneficial to the environment.

CONCLUSION

I recognise the frustration of Governments, Councils and the recycling industry in relation to what subsequently happens to the materials collected kerbside and processed at MRFs, but we must consider all the available/feasible/sustainable/economical options before rushing headlong into establishing non-viable plastics waste reprocessing operations in order to replace the industrial capacity that has already been proved as not viable in China, Malaysia and elsewhere in societies with very much lower wage and power costs than those in Australia.

I would be happy to supply further information or answer questions should it be necessary.

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Addendum: Are We Using The Most Suitable Plastics In Our Products?

ADDENDUM: ARE WE USING THE MOST SUITABLE PLASTICS IN OUR PRODUCTS?

INTRODUCTION

The basic point that I will attempt to make is that while it is wholly appropriate for the community and regulators to be concerned about the most environmentally sustainable way in which materials/resources currently in our waste streams are managed, there is insufficient emphasis being placed on examining whether we could choose alternative materials in certain applications which could be used much more sustainably then the current ones.

For example should it be found/deemed that some currently used plastic materials, with little or no hope of efficient reuse/recycling, could be replaced with others that can be sustainably managed, it could take a couple of decades or more to actually get such a changeover implemented since it would take that long for current investments in raw material manufacturing and processing hardware to be fully depreciated. Below I have concentrated on the use of plastics in packaging and discuss potential long-term strategies for the use of different plastics which can be reused/recycled more sustainably. The same type of arguments may be used for plastics in other applications.

The phenomenal technological advances in polymers, in particular thermoplastics, during the past 50 years and their eminent suitability for packaging applications have resulted in their huge success not just in replacing the more traditional materials used in earlier times, but also in the development of totally new packaging concepts.

Plastics used in packaging offer one or more of the following attractive properties/advantages:

- Cheapness and/or cost-effectiveness.
- Safeguarding the contents and/or the user from the contents.
- Preservation of the value of the contents for a desired period.
- Hermetic sealing.
- Security - 'childproofness'.
- Ease of opening.
- Light-weight solutions.
- High strength and toughness.
- Rigidity, or flexibility.
- Versatility in optical properties: transparent, translucent, or opaque.
- Good barrier to bacteria and other micro-organisms, hence hygienic.
- Good barrier to moisture, and high wet-strength.
- Good barrier to gases such as oxygen and carbon dioxide.
- Good barrier and resistance to chemicals.
- Resistance to high and/or low temperatures.
- Easy to process on high-speed equipment.
- Easy to print/decorate.

- Attractive presentation of packed contents.
- Reusability as materials (but not always).

What is more, the availability of high-performance packaging made from plastics has enabled significant product innovations in the food and drink industries. These segments have been the most significant growth areas for plastics in packaging in recent years. These convenience packages for foods and drinks have fitted in with and made easy the radical changes in our lifestyles over this period, such as, for example, the two working parent families. Very substantial improvements in food and beverage safety, hygiene and shelf-life are enabled by today's advanced plastics packaging technology.

Similar advances have, also, been made by plastics packaging in the manufactured goods and chemicals area as well.

The other major change which took place simultaneously was the revolution in advertising and marketing of foods, drinks and other manufactured goods. Packaging is seen as a vital part of a product's image and over packaging, by the users of packaging, to almost ridiculous degrees is one of the results of these new commercial strategies.

DISCUSSION

Current Situation

The above developments have been made at such a rapid pace that, except until relatively recently, insufficient attention has been directed to the responsible management of materials used in packaging at the end of their useful life. We can thank our environment conscious friends for bringing this important topic permanently onto our daily agenda. It is quite unrealistic, however, to expect that people should give up the significant benefits which such convenient packaging enabled them to enjoy. Having said that, I believe, nevertheless, that the only types of packaging, made of plastics or any other materials, which can hope to survive in the long-run are the ones which:

- Satisfy their 'Primary Role'.
- Meet as many of their 'Secondary Roles' as are feasible or are mandatory.
- Comply with the requirements of their 'Tertiary Role'.

The descriptions of these three 'Roles' are given below.

The Primary Role Packaging.

To act as a protective shield which ensures that the goods packed in it arrive safely at their final destination in an undamaged and fit state to be used for the intended purpose within a reasonable period of time after packing.

The Secondary Roles of Packaging.

These roles are requested/designed in by the producers/distributors of the packed goods fulfilling the following purposes:

1. Improving the appeal of the product to the would-be buyer/user, by employing eye-catching decorative designs. Using the pack for marketing tactics/promotions.
2. Identification of the producer/manufacturer and/or distributor.

3. Coding for automated check-out and stock control operations and/or sales price indication for the convenience of the reseller.
4. Protection of the contents against undetectable (malicious) tampering.
5. Protection of the contents against excessive abuse.
6. Basic description of the contents and/or instructions for the user (if required).
7. Product identification, detailed description of the contents, which is required by law, and/or dietary information, including the presence of any potential allergens.
8. Special features, making the end-use easier and/or more convenient (ease of carrying, dosing, resealing/storing, and aiding further processing such as cooking/reheating).
9. Protection against access to hazardous contents by children.
10. Use by date for contents which deteriorate and become unfit for use after a certain time.
11. Safety instructions and medical advice in the event of unintended use.
12. Other requirements of the packager.

The Tertiary Role of Packaging

Once the packaging has played out its primary and secondary roles, it becomes redundant and must be managed in an appropriate manner. The ability to be managed appropriately once it becomes redundant is this most important Tertiary Role of packaging. In some situations the packaging may be reused, but in most cases, at present, it becomes garbage, or worst still, litter. It is an even more challenging task to design for this Tertiary Role than for the previous two.

Today, most societies and their governments are beginning to expect or even demand, by means of legislation, that:

1. No more than the minimum feasible mass of materials be used in order to achieve the Primary Role of the Packaging plus any Secondary Roles that are deemed essential or are required by law.
2. The materials from redundant packaging be converted into something useful and, more specifically, in most cases, that they be recycled as materials.

The requirements for the Tertiary Role are constantly evolving.

The Role of the Packaging Industry

In order to survive the packaging industry must design and produce cost-effective packaging which arrives at the best trade-off between the requirements of the above 3 Roles at a selling price which the customer can afford and which achieves its own reasonable expectations of profitability.

The industry must ensure that the design of any new package component should allow for a cost-effective and responsible management of its constituent materials when the pack becomes redundant.

The industry must also continue to work with its raw-materials suppliers, customers, recyclers, potential users of recycled materials and, when necessary, users of thermal energy, on ways and means of minimising the losses in the value of materials and in our precious non-renewable resources which have been used in packaging.

Why Is Plastics Packaging Subjected to Criticism?

Problems for a particular type of package may arise from an environmental viewpoint when one or more of the following apply:

1. Irresponsible disposal by the end-user, or others involved in the subsequent waste collection process. (The terrible pollution of our oceans with plastics, and foamed polystyrene packaging of fast foods are good examples of this.)
2. The use of more than the minimum feasible mass of materials needed to achieve the essential primary and secondary roles. (Blister packaging of small items in large packs, biscuit/confectionery packaging in three part packs and poor quality carry-bags, which need to be used one inside another, are examples of this type of wastage.)
3. The use of certain materials, or a combination of materials which makes their subsequent reuse as materials problematic, expensive, or cost-ineffective. (Laminates of plastics with paper and/or metal foil, and multi-layer combinations of incompatible polymers would serve as examples.)
4. The use of one or more of the materials which are proven to be environmentally unacceptable. (I doubt that there is definite proof, as yet, that any material used widely in packaging fits this category.)
5. The component itself is 'modified' by the packager, by combination with other materials, in a manner which makes the reuse of the material(s) more difficult/expensive. (Examples are: difficult to remove labelling, printing, affixed components, etc.)

The need for many of the secondary roles which can in turn lead to one or more of the above problems can be debated. The points of view of all of the parties involved in the chain can be, and often are, different. Nonetheless, it is not possible for the packaging industry to force its view on its customers the packagers, their customers the retailers and their customers the consumers. All concerned must share the responsibility for such decisions.

Should We Use Multi-Trip or Single-Trip Packaging?

This is a topical question, and I have a good illustration since during my overseas assignment in The Netherlands I was responsible for the development of a multi-trip (at least 40) washable-refillable carbonated soft-drink bottle:

Even at 3 times the mass of a one-way/throw-away PET bottle, the 'mass of plastic used per trip' (for 40 trips) for this refillable bottle is 13 times smaller than for the PET bottle.

This may appear to be an easy choice in favour of the reusable bottle, yet it isn't - by a long shot!

There are other factors to be considered before one can say which package is preferable:

1. During every trip the bottle is washed in a process which uses quite a lot of water. This solution is fine in Northern Europe where there is plenty of good quality (clean) water available at a low price, however, I would doubt if this solution would always work in Australia where sometimes water is very scarce, Thailand which has a polluted water supply or Saudi Arabia where water is expensive.
2. A cost-effective infrastructure needs to be in place for collecting the empties and returning them for washing and refilling at the place of purchase. This was, already, in place in Northern Europe for glass bottles and the change to plastic bottles was not difficult. Such a system is not in place in Australia, the United States and many other countries, where a change to reusable bottles could be very costly. Such multi-trip packaging may work well for densely populated areas such as Sydney, Newcastle and Wollongong, while single-trip packaging may still be more efficient for the more remote rural regions of NSW.
3. The abuse and misuse of bottles present an element of risk to such a system, and the thorough cleaning of all bottles and the fail-safe isolation of contaminated and damaged

containers is essential for the sake of public safety and of convenience, respectively. This aspect varies from country to country both with respect to the extent of abuse and the ability to cope with the resultant damage.

4. The consumption of energy, water, cleaning agents and the generation of pollutants in the collection, transport and washing of such bottles, needs to be estimated and costed and then taken into consideration before a comparison with the alternatives are made. In Northern Europe with relatively small distances between the filling and the retailing locations, reusable bottles appear to be a cost-effective solution. Again, as in 2., this may limit the areas of application to densely populated ones.
5. The reusability and intrinsic value of the bottle materials at the end of their primary use, are important factors to be considered, as is the environmental pollution associated with their reuse or disposal in other ways. This implies, also, the availability of equipment for the cost-effective reuse or disposal of the materials.
6. Is it possible to keep separate at source, or to isolate at the reuse or the recycling destination this type of package from other types of packages?
7. The availability and cost of base materials, and if unavailable, the cost of their development for local production, or the tariffs and duties payable when importing them.

Legislation and government policies, unfortunately, tend to precede the availability of reliable scientific data because of the need for regulators to respond to 'public opinion/perceptions' which are sometimes based on scanty and unproven, yet highly publicised, data/information from 'well-intentioned' pressure groups. The formation of dioxins during garbage disposal from chlorine containing plastics, such as PVC, is one such example.

The above shows the challenge which package developers, designers, suppliers and users face, namely, that the 'right package' is often dependent on the locality in which it is produced and/or used. One cannot expect to be able to apply the same solution for the packaging of any particular product irrespective of the local and/or global (export) circumstances.

How To Choose The 'Right Material(s)' For A Packaging Application?

All interested parties, such as materials suppliers, packaging manufacturers and environmental activists appear ready and able to produce complex evidence, involving intricate mathematical calculations, such as 'eco-balances'/'life-cycle analyses', in order to justify their point of view about the suitability or unsuitability of a particular material.

How does the packaging industry, or for that matter regulators, determine what is the 'right solution'? Obvious answers to such questions are rare, since the solutions vary according to the basic assumptions made and to the fixed criteria of a given locality. Yet the right solutions must be found in order to- ensure that our scarce natural resources are conserved and that the businesses involved in this industry can survive.

There are 4 distinct potentially ecologically sustainable options for the management of packaging at the end of their use which need to be evaluated in a proper 'life-cycle assessment' for any existing and proposed (replacement) packaging solution (when and as applicable):

1. the packaging can be used again either with or without cleaning,
2. the material can be recovered and used again in packaging,
3. the material can be recovered and used again in an application other than packaging (this can be a problem because packaging uses much larger quantities of materials than many other applications), or

4. the 'energy' locked-up in the material can be efficiently recovered.

If it is the aim of all concerned to arrive at the 'best possible' material/solution, all precedents and preconceptions should be ignored - this means that even materials which are currently considered 'too expensive' for packaging should be given some consideration.

Plastics used in packaging can be divided into 2 main groups:

- 'commodity plastics' which are currently manufactured in large quantities and are relatively cheap, and
- 'higher-performance plastics'/'specialty plastics' which are manufactured in smaller quantities and are often more expensive.

'Commodity plastics' (such as polyethylenes, polypropylenes and polyvinyl chlorides) are usually of such a chemical structure that they cannot be readily converted back to the chemical substances (ethylene, propylene or vinyl chloride) from which they were formed. It is often very difficult to 'clean-up' (from contamination by chemicals or even by other plastics) such materials so that they may become suitable for use as a raw material in packaging (especially food packaging for which there are special legislative provisions) or even other applications. Commodity plastics can, however, be cleanly and efficiently turned into 'energy' by new processes using 'gasification' and/or 'hydrogenation' technologies which break such plastics down to a mixture of 'fuel gases' which, however, are not suitable for remaking plastics.

Some 'higher performance plastics', which are often manufactured by processes known as 'condensation polymerisation', on the other hand, can be readily broken down by more specific chemical means into their 'building blocks' which can then be purified and re-polymerised/re-converted into new 'virgin' plastics. This type of reprocessing enables their use in packaging which is in direct contact with food while simple 'mechanical recycling' will generally not since the latter process usually does not guarantee the removal of potentially toxic contaminants.

When considering alternative materials for any packaging application, it is advisable to begin with 'all available materials' and, then, whittle this 'list' down by a process of elimination. No material should be eliminated from consideration on the basis of current high prices, for the following reasons:

i. Raw materials suppliers may be 'lured', by the large volumes available in the packaging arena, into price reductions.
ii. Higher performance material(s) may enable significant reductions in the mass required to attain the desired performance, resulting in a more cost-effective solution than when using cheaper material(s) .
iii. Higher performance material(s) may satisfy the required roles of the packaging either in a single-layer structure, or in a much simpler multi-layer structure. In fact, it may be the only sensible solution able to meet all of the required roles of the package.
iv. Higher performance materials may enable the package to be used many times, and result in both cost-effectiveness and in environment friendliness.
v. After recycling, higher performance materials often tend to retain most of their superior properties and, therefore, may be used in higher-value subsequent applications. This higher 'intrinsic' value of such recycled plastics, as compared to their commodity plastics counterparts, would enable their reuse to be cost-effective.
vi. Higher performance materials may be of such a type which may be readily broken down chemically into its original building blocks and then recycled by making new high performance plastics from those recovered building blocks (as mentioned above).

For each potential package type, the feasibility and cost-effectiveness of, either reusing the materials, or converting the materials into energy must be examined. All of those which cannot even be efficiently and cleanly converted into energy need to be isolated/discarded.

Package designs with the aim of driving the total mass of material(s) to be used down to the lowest practicable level(s) need to be drawn up. (It is a pity that it is not practical to use spherical containers more often, since that shape uses the least mass of material for any given volume!)

Package designs must be costed and ranked in terms of cost-performance under two separate headings, namely, 'Material Recyclable' and 'Only Energy Recyclable'. Should an 'only energy recyclable' option be the cheapest, the most cost-effective 'material recyclable option' (if any) should be considered in order that an appropriate final choice can be made.

CONCLUSION

I would not be surprised that if we went through open-minded and exhaustive material selection processes, such as the one described above, we will eventually not only see changes in the type(s) of plastic material used for certain packaging applications, but also in the (recycled) materials used cost-effectively in other manufactured products. One could also expect a significant reduction in the number of different types of plastic materials used for packaging which in itself should make the separation and reuse of plastics more easy and economical.

The aim of plastics packaging should be to perform the roles expected and required of it effectively. It should be the regulators' aim to ensure that the relevant industries and the community at large work together to minimise the losses in the value of the materials and in our precious non-renewable resources which have been used in packaging. We do need time, resources, and the co-operation of all concerned in order to find permanent and cost-effective solutions to the challenges of responsible disposal/reuse of all plastic materials and not only those used in packaging.

Because of the complexity of the issues involved and the implications to long-term investment by the chemicals, packaging and retailing industries, I believe that this will not happen soon enough unless the Government takes the initiative to 'force it to happen'.