Driving energy and resource efficiency through chemical engineering

Material Recovery from Discarded Electronic Devices

(Dell and the Circular Economy)

Introduction

The world is experiencing growing amounts of electron waste (e-waste), driven primarily by the increasing use of electrical and electronic equipment. The key underlying factors for this increased use or electrical/electronic equipment are urbanisation, higher disposable income levels, rapid industrialisation in developing countries, the general global move to an information-driven society/digital economy.

Disposal of electronic devices once they reach their normal life is a major issue. E-waste such as discarded personal computers (PCs), laptops, tablets, mobile phones and other electronic devices, is a fast-growing municipal waste stream. The global volume of e-waste generated reached 44.7 million tonnes in 2016.[1] Of this, only 20% was recycled.

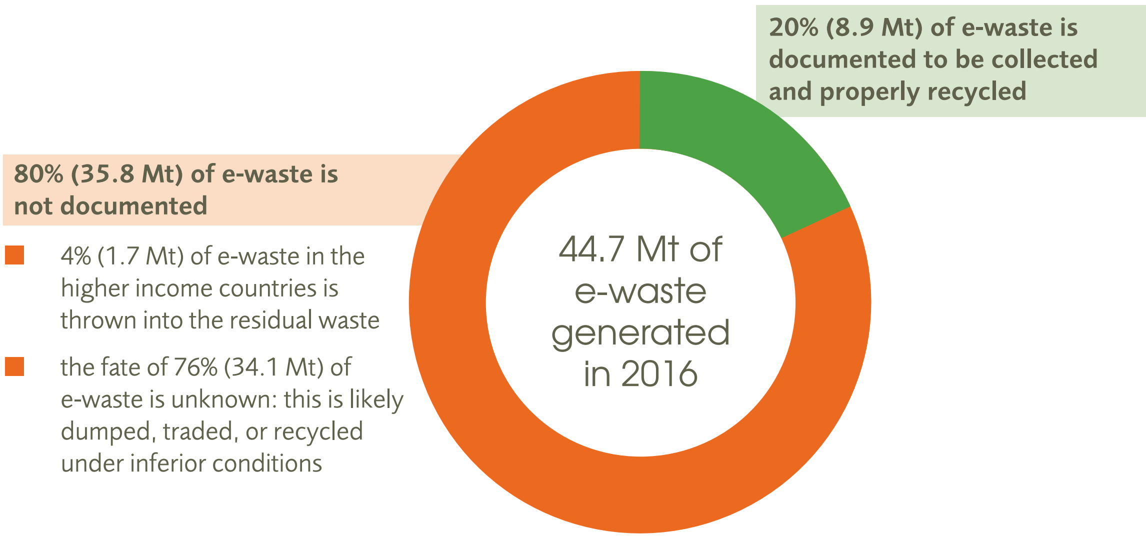

Figure 1: Global volume of waste generated.

In 2017, only 41 countries collected statistics on e-waste. In the EU the treatment of e-waste is regulated by the Waste Electrical and Electronic Equipment (WEEE) Directive and similar legislation at both Federal and State levels in the US. This legislation sets collection, recycling and recovery targets for all types of electrical equipment and provides for the creation of collection schemes where consumers return their obsolete devices free of charge. The schemes aim to improve the environmental management of WEEE and to contribute to a circular economy and enhance resource efficiency.

[1] *International Telecommunications Unit (ITU), Global E-waste Monitor 2017: Quantities, Flows and Resources, 2017,* ***http://bit.ly/2P4AFGA***

Despite legislation, considerable quantities of electronic devices which have become obsolete in the developed world are sent to developing countries either for reuse or ostensibly for recycle. There is however no check on how this material is processed or disposed of and evidence would suggest much of it is dumped into landfill. Most devices contain some environmentally harmful materials which must be properly handled, and this classifies them as hazardous waste making them unsuitable for landfill. In addition, some of the metals these devices contain are rare and extremely valuable. The value of raw materials found in e-waste was estimated to be €55 bn (over US$60 bn) in 2016, which is higher than the annual revenue of Singapore, Kuwait, Cuba, Algeria, Malaysia, as well as about 180 other individual countries.[1]

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Figure 2: E-waste dump.

A Solution

Much of what is classified, as e-waste is electronic equipment or components that can gain new life through reuse or recycling. Recycling results in less air and water pollution, lower greenhouse gas emissions and conserves energy and natural resources thus reducing the environmental burden.

To set an example, Dell has established itself as an industry leader in terms of its environmental performance both for its in-house operations and for its product stewardship. It was one of the first companies to offer to take back customers obsolete computers at no cost and it has set challenging targets for the way it handles this equipment.

In this sense, Dell is moving away from the linear economy of take-make-dispose towards a circular economy, maximising the value of materials by ensuring that they are in use for as long as possible, thereby minimising/eliminating waste. To do this, careful thought goes into its overall process from the stage of design of products to operational processes. Opportunities are identified to close the loop by keeping materials to be used for as long as possible in a circular way eg recycled/reused electronics, etc. To do this effectively, it is very important to think about this from the very onset at the design stage eg Dell limits the use of glues for electronics, and uses snap fits and some other types of design considerations to make it easier for materials to be dissembled for separate recycling.

Plastics

Dell have used recycled plastic from various sources, including plastic bottles, in various products since 2008. In 2014 they pioneered the use of closed-loop plastics from e-waste recycling streams taking the plastics from old computers recovered through their recycling programs and turning that back into new plastic parts for new products. These efforts all support a target to use 100,000 tonnes of recycled plastic and other sustainable materials in their products, representing about 0.8% of the total global plastic e-waste (12,230 kilotons in 2016[2]). By the 2017 financial year, Dell used over 7,940 tonnes of recycled plastics in their products. Of this, 2,440 tonnes came from closed-loop streams and over 4,500 tonnes from post-consumer recycled plastic (eg water bottles).[3]

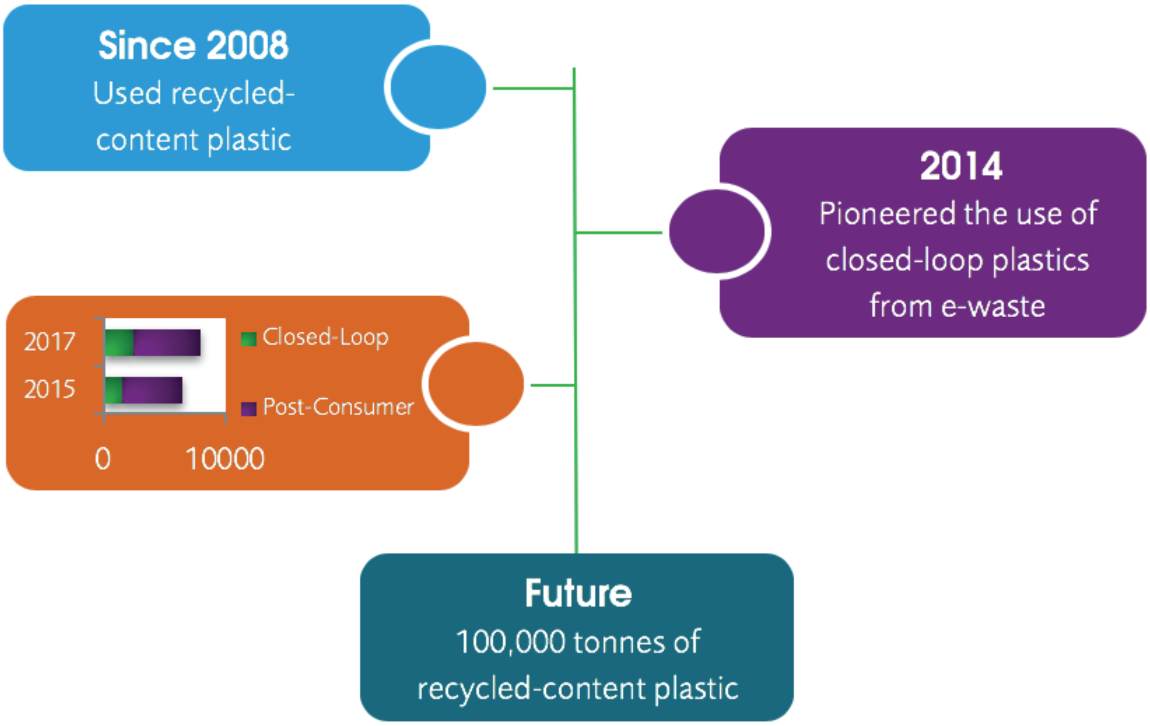

Figure 3: Use of e-waste in Dell products over the year.

The plastics are separated into types and shipped to Dell's manufacturing partners in China. When the plastics arrive, they are shredded at the manufacturing facilities, melted and blended with virgin material (currently with 35% recycled content), then moulded into new parts. Closed-loop plastics are used in parts for more than 90 different products (as of June 2017) and it takes approximately six months for the materials to go from an old computer, get melted down and turned back into a new computer. Meanwhile, other materials from the computers are similarly recycled and separated, then sold on the commodities market for reuse by others.

An independent study published by TruCost in 2015 showed that this closed-loop process (see Figure 4) yielded a net benefit worth US$1.3 million annually compared to the use of virgin plastics.[4]

2015: **6,400** tonnes of recycled plastics in products (**1,500** tonnes from closed loop)

2017: **7,300** tonnes of recycled plastics in products (**2,450** tonnes from closed loop)

[2] *International Telecommunications Unit (ITU), Global E-waste Monitor 2017: Quantities, Flows and Resources, 2017,* **http://bit.ly/2P4AFGA**

[3] *Dell, FY17 Corporate Social Responsibility Report, 2017,* **https://dell.to/2EmVWr7**

[4] *TruCost, Valuing the net benefit of Dell's more sustainable plastic use at an industry-wide scale, 2015,* **https://dell.to/2OOCxUL**

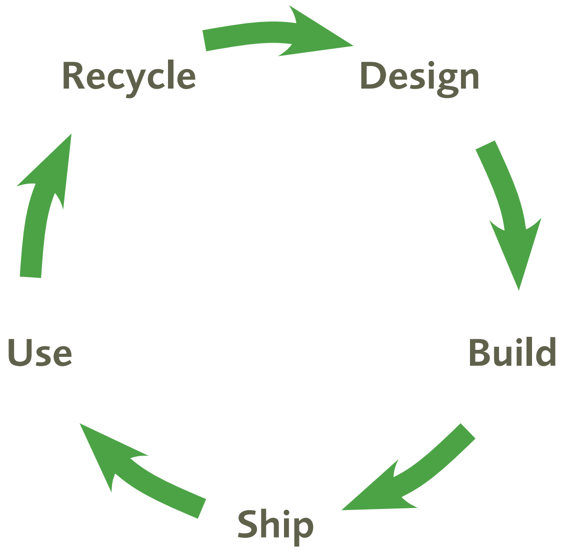

Figure 4: Closed loop recycling process.

Metals

In January 2018, Dell became the first PC manufacturer to use recycled gold from e-waste in its products which made it the latest addition to the portfolio of reclaimed, recycled-content and closed-loop materials used in its products.

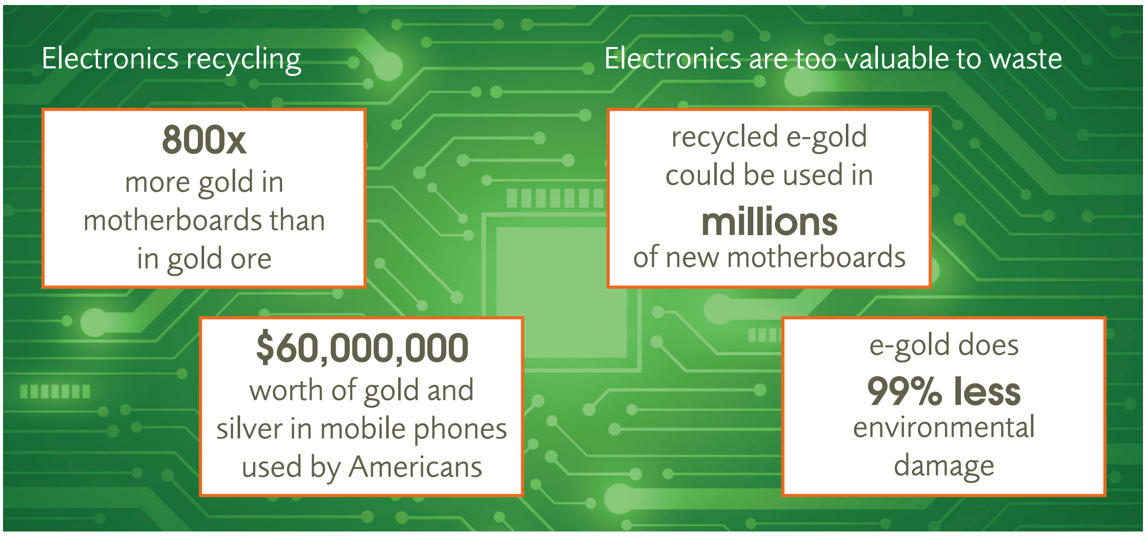

Figure 5: Adapted from Precious metals in e-waste ***www.dell.com***

While the amount of gold used in any individual component is very small (on average Dell uses about 3,175 kg of gold in its products every year)[5] the amount adds up quickly when totalled across the many computers, cell phones and other electronic devices produced. Because recycling rates for e-waste are still low (globally below 15%), a lot of these precious metals exit the economy. In the US alone, consumers throw away US$60 million in gold and silver each year by not recycling their phones.

In computers, by contrast, a tonne of used motherboards has up to 800 times more gold than a tonne of gold ore. By capturing and reusing gold from obsolete electronics it is possible to reduce the environmental and social footprint of such products while supporting a broader shift to the circular economy.

After Dell harvest the recycled stream for electronics that can be refurbished or stripped for parts, they 'mine' the remaining e-waste for gold in the same way as for closed-loop plastics.

[5] *Dell, Technology with a heart of recycled gold,* ***https://dell.to/2RSgURl****, accessed 16/10/2018*

Dell's partner, Wistron Green Tech, a Texas corporation, extracts the gold from motherboards electrochemically and then melts the gold into bars for easy transport. This is a more environmentally friendly process than the pyro metallurgy used conventionally in the industry. Dell's pilot project shipped 2.27 kg of gold to its suppliers in Taiwan who used it to create a 'gold salt bath'. Components for new motherboards were then dipped in this bath to coat them. Rather than incinerate the plastic and fiberglass in the motherboards, Wistron also recycles this material for use in new electronics devices.

An independent study found that the closed-loop process can cause 99% less environmental damage.[6] It avoids US$1.6 million in natural capital costs per kilogram processed (US$3.68 million for the pilot project of 2.27 kg of gold alone) when compared to gold mining. The same study showed the closed-loop process avoids 41 times the social impacts of gold mining.

Lessons for chemical engineers

- closed-loop plastic recycling avoids significant environmental impacts that should be considered alongside financial costs of virgin plastic procurement
- not all plastics can be recycled and incorporated back into products
- consideration of the contaminants eg flame retardants in the waste stream is essential
- end-of-life considerations must be taken into account at the product design stage particularly in the choice of materials and the selection of construction systems which aid disassembly
- closed-loop recycling avoids significant environmental impacts and can reduce the consumption of often rare virgin raw materials as well as delivering economic advantage
- novel separation processes that chemical engineers are best suited to develop often require research

[6] *Trucost, Dell: Environmental Net Benefit of Gold Recycling, 2017,* **https://dell.to/2pVAW0t**

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