# How Green is Our Green?

# A Sustainability Assessment of U.S. and Australian Currency


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**Metal, Paper, or Plastic?**

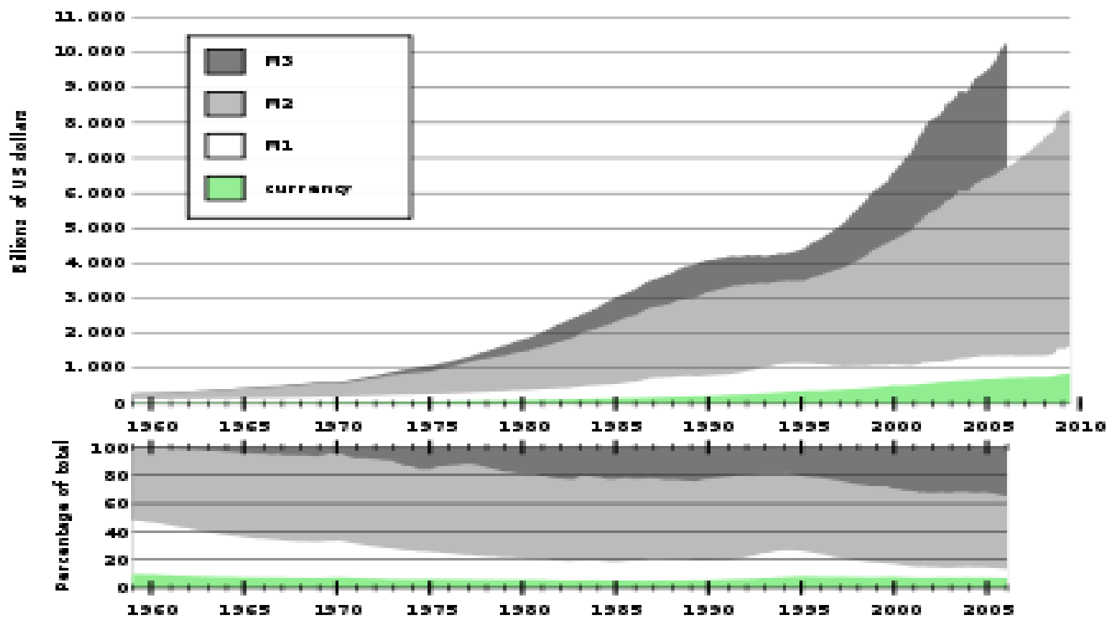
People have used a wide variety of materials for currency, everything from shells to precious metals to, most recently, plastic. The materials used are indicative of the social and political climate of the time period, as well as available technology and resources. Today there are many mediums of exchange recognized internationally such as the Euro, and the American, Australian, and Canadian dollars. As we strive to become a more sustainable society it is vital that we examine our actions and how we can become less wasteful, even when it comes to our currency. For this reason we have investigated zinc, copper, manganese, nickel, ragged paper, and polymer; materials used to make currency throughout the world. We have assessed the sustainability of using each of these materials to determine which would be the best choice for the future of U.S. currency.

**Economics of Paper Money Printing**

The Bureau of Engraving and Printing (the BEP) has been printing Federal Reserve Notes annually for the Federal Reserve System since 1877. Today, it prints money in its two locations Fort Worth, Texas and Washington, DC. It has printed money along with postage stamps, government obligations and other security documents. However, it does not produce coins. The United States Mint is in charge of all U.S. coinage (BEP, 2010). The BEP prints paper currency in denominations of

$1, $2, $5 $10, $20, $50 and $100. Larger denominations were printed for transactions between the Federal Reserve Banks, but were discontinued in 1969.

Printing production, regulated by the Federal Reserves, is depicted in the graph below (courtesy of Wikipedia):




The Federal reserve System tracks the total of all physical currency plus any of the assets of the central bank. That amount is called "vault cash" and is added to the amount in checking and other current accounts (demand accounts)(M1). Also measured are savings accounts, money market accounts and small certificates of deposits (M2). CDs, deposits of Eurodollars and repurchase agreements are also measured (M3). After all of the money is measured and accounted for, the BEP determines how much currency must be printed, a number reported annually. Last year productivity fell by 7.8% primarily due to the decrease in the currency order. It is calculated based on units of output per labor hour, which means that for every hour the average worker put into the production of currency, the amount produced decreased on average by 7.8%. (BEP, 2010).

Recently new changes have been made in the printing of currency mainly due to new security features added to the bills. The BEP invested in new equipment to print money with these new security measures, such as metallic inks and other new technologies aimed at fighting counterfeiting. As a result, the 2009 increase in net property and equipment was $26 million, with a grand total a total of $308 million. That same year, the cost per thousand federal-reserve notes had a standard price of $32.82 and an actual cost of $31.55. The currency decreased by $14 million in total compared to the previous year. Due primarily to the decrease order last year, productivity fell by 7.8% and is estimated to decrease more this year. However, in 2009 the BEP produced approximately 26 million notes a day with a face value of approximately $907 million. It is estimated that about 95% of the notes printed each year are used to replace notes already in or taken out of circulation (BEP, 2010).

**Paper Currency Production**

All of the paper used for printing money is manufactured at the Crane Paper Company in Dalton, MA. The paper is made from a blend of 75% cotton and 25% linen. The majority of the cotton used is recovered waste fiber from garment manufacturing industries around the world. The origin of the cotton varies all the time, based on quality, availability, and price. When not using recovered cotton, staple cotton grown in the Southwestern United States is used as a supplement. The linen used comes from fibers that are not suitable for manufacturing linen textiles. Before these fibers can be used they must be refined chemically and mechanically to remove impurities such as natural oils. This is done by first cooking the fibers in sodium hydroxide. In solid form NaOH is not mobile in soil, however, it dissolves easily in water and can be leached into soils, causing water contamination. Also, the fumes produced are highly toxic and can result in skin, eye, nose, and throat irritation (Lenntech). Sodium hypochlorite (used in bleach) is used to brighten the color of the fibers. NaOCl, when mixed with acids, creates a toxic chlorine gas. NaOCl is also acutely toxic to fish (Labour Environmental Society). About 100 pounds of thread are used each day to produce about 45,000 pounds of paper each day. The manufacturing process is extremely water intensive because the stock must first be 99% water and 1% fibers. By the time the process is complete, the stock is 5% water. About one million gallons of water is used each day for this process. The water comes from deep wells on-site. The production process is estimated to be very energy intensive as well, though information about actual usage has not been made public (Crane Currency).

Although the paper making process is very water and energy intensive, Crane Paper has developed ways to reduce and reuse waste, as well as utilize diverse forms of energy production. More than 70% of the energy used in the process comes from an incinerator plant on-site. The "Energy from Waste" plant incinerates municipal refuse from the paper making facility to generate steam used for the company's manufacturing operations. As a result, Crane saves more than 2 million gallons of oil per year and emits up to 78 percent fewer greenhouse gases. Crane is also in the process of building a water turbine that will harness power from the Housatonic River, and will provide about 30% of the energy used on site for the paper making process. Crane has also developed ways in which to recover water at different parts of the production process and is able to reuse it whenever possible. Crane also captures heat from the papermaking process and extracts it to heat water for later processing thereby saving not just water but energy as well. They have also developed an on-site wastewater treatment facility that can treat up to seven million gallons per day. The treated water is released into the nearby Housatonic River and the leftover pulp and other organic solids are composted and used as topsoil in the Northeast for cover in decommissioned landfills (Crane Currency).

Once the paper making process is complete, the paper is shipped to either the Bureau of Engraving and Printing's Fort Worth, Texas, or Washington, DC facilities. Several blends of oil-based inks are used to give the paper the required color and design. Green, black, metallic, and color-shifting ink are all specially blended by the BEP. Information on the chemicals used in the inks is not readily available from the BEP for fear of counterfeiting. The majority of the air emissions are Volatile Organic Compounds (VOCs), emitted during the printing process and primarily related to the inks and solvents used. Ozone formation can occur when VOCs react with Nitrogen Oxides (NOx) in the presence of sunlight. As a result, VOC emissions can contribute to ground-level ozone pollution and global climate change. In 2002, VOC emissions related to the production process were at 55.05 tons per year in the DC facility. Other waste streams produced by BEP are wastewater and solid wastes generated mainly from waste note sheets and trimmings. The majority of these spoils are incinerated on-site (Potomac Hudson Engineering).

Both facilities have industrial water pre-treatment plants that treat wastes before discharging it to the local Publicly Owned Treatment Works. The BEP branch in Washington generally uses an average of 245,000 gallons of water each day. Although much of this water is treated and some is recaptured and reused, the vast amount of energy required to do so greatly contributes to greenhouse gas emissions. The electricity used in the DC facility comes from a natural gas provider, Washington Gas, as well as Federal steam generation from local facilities. Energy consumption rates in 2002 were 53392 MWH of electricity, 43662 CCF of natural gas, and 93.8 BBTU of steam. The facility in Fort Worth receives its electric and natural gas needs from TXU Electricity. The company generates more than 18,000 megawatts from coal, natural gas, and nuclear generators. In 2002, rates were 44441 MWH of electricity, and 119540 CCF of natural gas (Potomac Hudson Engineering).

The solid waste generated from inks and cleaning solvents are the majority of the production waste stream. The ink, water, and wiping solution are first pretreated before disposal to the local treatment plant. The solids that are filtered out are put into recycled 55 gallon drums. The waste generated in the DC facility is hauled to a landfill in Model City, NY, while the facility in Fort Worth is shipped to one in Oklahoma. In 2002, DC generated 3,785,500 lbs. of sludge waste and 2,324,358 lbs. in Texas. This waste stream greatly contributes to both ground and air pollution, especially through the trucking required to transport the waste to its final destination. Both the DC and Texas facilities are classified as a large-quantity generator (LQG) of hazardous waste under the Resource Conservation and Recovery Act, at more than 1,000 lbs. of waste per year directly related to the production process (Potomac Hudson Engineering).

Recently, the BEP has been planning to improve material recycling during production processes. The bureau plans to install a new wiping solution recycling system that will save approximately 15 million gallons of water each year. Also, through better recycling, re-use, and remanufacturing management and techniques, they have managed to divert 2.5 million lbs. of solid waste from landfills (BEP).

**Social Impacts of U.S. Currency**

As of 2008, it was estimated that there were 304,060 blind and 4,067,309 visually impaired people living in the United States. “Visually impaired” denotes someone who has difficulty with sight, though they have some useful vision. These groups account for millions of people who feel vulnerable and regularly need help when using cash for transactions. Many blind and visually impaired citizens have reported that they had given the wrong currency during transactions and that they also have received the wrong change before. Of over 180 countries that use paper bills, ours are the only bills that do not distinguish between denominations through varying size or noticeable textural differences. Some recent adjustments to our currency has included the placement of a large, purple numeral in the corner of some bills, and infrared numbers in the corners for bill scanners (Andrews, 2006).

While a visually impaired person may be able to read these large characters on a five-dollar bill, they can do so only at a close distance. Tests while holding the bill's at an arm's length had low success rates (ARINC, 2009). Someone who is blind cannot see this character at all. Currency scanners available to the public are often expensive and very inaccurate (Stout, 2008). U.S. bills also feature intaglio, or raised, print but this wears down rapidly on the paper bill and becomes indistinct. These measures were developed more for counterfeiting than to help the blind and visually impaired (ARINC, 2009).

In 2006, a federal judge ruled that our current U.S. currency system violates the Rehabilitation Act by discriminating against the blind and visually impaired. The case has since gone through several appeals, but as of 2010 the decision has been upheld. While the government has argued that completely redoing our currency system would be very costly, the judge pointed out that $178 million for new presses and $50 million for new printing plates would be a meager sum in comparison to the $4 billion spent on currency in the decade prior to his ruling (Andrews, 2008). Many countries have adopted measures to make bills more easily distinguishable for citizens who cannot see them. There are raised dot clusters on Canadian bills, which were found to be 89% effective in a study commissioned by the Bureau of Engraving (Stout, 2008). Euros vary in size, Japanese currency sports rough patches, and the Swiss bills are perforated to make life easier for those with little or no sight (Andrews, 2006). Other bills have notches on them or embedded substrates to differentiate the worth of each bill (ARINC, 2009). The United States needs to change their currency to make it usable by all of its citizens, not just those who can see it.

**The Golden Dollar**

The Sacagawea dollar coin is made of 77% copper, 12% zinc, 4% nickel, and 7% manganese, all of which can be found in mining operations worldwide (Wu, 2000). All U.S. coinage in denominations smaller than the dollar are comprised of the first three metals. Rather than create coins of the pure metals, which would be far too expensive, they are made from alloys. These alloys are beneficial not only because they are cheaper, but also because they are more stable. For instance, the production of the pure copper penny was discontinued in 1982 (Velde, 2008) when the price of copper was $1.40 per pound. A pound of metal made 154 pennies, and the large quantities of small change being distributed raised alarms that scraping pennies would soon become profitable. The pure copper coin was also subject to oxidization. Since the composition for the penny has become 2.5% copper to 97.5% nickel, it has alleviated the potential problem of melting coins for profit. History has shown that when the face value of a coin is less than the worth of the metal that it is made of, they start to disappear (Perkins, 1992). The altered composition also provides the coin with durability and longevity as the nickel prevents oxidation of the copper. Nickel, considered rare (McInnis, 2010), is an expensive metal in terms of its weight to price and historically has been used in smaller amounts than mixed with copper.

The U.S. Mint released their first dollar coin back in 1979, a silvery nickel and copper blend emblazoned with a portrait of the famous leader of the women's suffrage movement, Susan B. Anthony. The coin was the same color and about the size of a quarter, which led to much confusion for citizens trying to use it. As a result, it was wildly unpopular. The treasury department began to understand their mistake many years later, which is why the Sacagawea dollar coin has been carefully crafted to pass for Susan B.'s in vending machines and other currency counting devices, but was given a luster equal to 14 carat gold. Though it involved numerous tests on various alloys, the U.S. Mint finally chose the copper-zinc-nickel-manganese alloy because the manganese brass made the coin gold (though manganese is usually used for pink coloring) and had the same electromagnitivity as the Susan B. Anthony coin (Wu, 2000).

**The Impact of Coins on Environment and Human Health**

In their lifecycle assessment of dollar coins and dollar bills, Claus, Shepherd and Wayne estimated that the production of both have roughly the same amount of waste. The difference is that metal waste from coin production and coins unfit for circulation can easily be melted back down and used to make new coins. Newly mined metal and old, recycled metal can be melted down and become indistinguishable. However, while some of the metals are easy to separate from each other, such as nickel and copper, others would require a higher energy input during the metallurgic process (McInnis, 2010).

On top of the issue of recycling is the physical impact that the original extraction of these metals has on the environment and human health. Though these metals are for the most part harmless to people, zinc, manganese, and nickel can cause metal allergies in some people (Claus, Shepherd, and Wayne). Their extraction is a different story. Oftentimes they are found in ores that also contain lead, cadmium, and other heavy metals, which have very serious environmental and health effects. Quarry pits, tailings piles, waste dumps, and deforestation mar the landscapes around mines (Juracek, 2007, Gswami, Mishra, and Das, 2009). Wastes from the mines often have detrimental effects on the environment and human health.

Copper mining has been a fundamental part of Michigan's economy especially in the Lake Superior region of the state, and is known worldwide as one of the best producers of copper in history (Rosemeyer, 2010). Other mines exist in Chile, Indonesia, and Australia (Fiscor, 2010). The waste that copper mines contribute to soil contamination and other pollutants from mining practices cause negative environmental impacts on living organisms. Copper is a natural bacteride, which means that it can kill microbes and can improve health by making money cleaner, but this has a negative effect on the environment (Claus, Shepherd, and Wayne).Lately there has been some research in copper resistant bacteria that are improving soil quality (Andreazza et al, 2010).

Zinc is an essential bodily nutrient, but anything can have negative effects on health when quantities exceed normal levels. Historically, the Ozarks have and continue to be large producers of zinc, with the entire United States being the fourth greatest producer of the metal. The top three are China, Australia, and Peru. Zinc is extracted through underground mining, open pit mining, or a combination of the two. Underground methods, which accounts for 80% of current mining operations, generally produces the most (Lee, J. 2008). These mines have torn away at the landscape. Galena, Kansas, for instance, has been reduced to “Hell’s Half Acre” by a nearby zinc mine (Juracek, 2007). A study conducted at Empire Lake in Kansas, nearby to the now defunct copper, zinc, and nickel mine, found that sediment concentrations “typically far exceeded the probable-effects guidelines, which represent the concentrations above which toxic biological effects usually or frequently occur.” (Juracek, 2007, p. 1462). Mining waste is often carried via runoff into neighboring lakes and streams. The waste then sinks to the bottom and upsets the natural balance of these bodies of water. The abundance of zinc can lead to eutrophication, during which excessive algae growth robs the water of oxygen, causing other biota to die off. Lakes, such as Coeur d’Alene in Idaho, can become an unnaturally clear shade of deep blue. It can bioaccumulate in fish and other lake creatures, and can contaminate nearby vegetation. In Idaho, though the metal levels were not high enough to be deemed as detrimental to human health, Trumpeter swans died after eating tainted plant life (Deneen, 2002).

Nickel mines have been productive in Russia, Canada, Australia and Indonesia. Like other mineral mines, nickel mines have containment dams set in place to prevent widespread pollution and contamination, but these containment areas are prone to faults and accidents which can have lasting and catastrophic impacts on the surrounding environment (Lasocki et al, 2003). Nickel itself has some carcinogenic effects, but these are not produced during the smelting or working processes (Claus, Shepherd, and Wayne). Nickel has an important role in our lives as one of the key components of stainless steel. As a result, the demand for the metal is very high, making it an expensive resource.

Manganese, used in a variety of different ways other than money, is in high demand in the United States. The U.S., however, contains a meager supply of the mineral, with the only deposits being of low-grade ore in South Carolina, used only for coloring bricks. All of the manganese used by the United States for batteries, fungicides, pesticides, and weaponry to name a few, must be imported. From 2004 to 2007 this manganese was brought in from Gabon. However, China is the largest producer of the pure metal and has ben described as the "dominant supplier" by Asian Metal Limited (Vulcan, T., 2009). It does not exist in nature on its on own, which makes its production more difficult and costly (McInnis, 2010).

The negative effects of manganese mining are all too prevalent for workers of and inhabitants near a mine in Orissa, India. Once-cultivated land has been rendered barren. Acidic runoff, wastes, and dusts from mining activity contaminate nearby water sources and change the pH of the soil. The water has an odd taste and a reddish-brown color. Affected land becomes acidic, making an inhospitable environment for bacteria. The reduction in bacterial activity means that the soil can become sterile and unusable. The effects on people are just as noticeable. Though manganese is an essential mineral for the human body (a lack of it is linked to epilepsy and osteoporosis) too much manganese can wreak havoc. Particulates from the mining process can be sent into the water and the air, where they can find their way into the lungs of workers and other people nearby. Inhalation of these particles can lead to burns of the upper respiratory tract, lungs, upper digestive tract, and other parts of the body. Higher manganese levels can cause sleep disturbances, disorientation, hallucinations, and can also tamper with reproductive viability. At the mine, male workers had reduced numbers of offspring, while female workers dealt with higher infant mortality rates (Gswami, Mishra, and Das, 2009).

**Corporate Issues Pertaining to Coins**

The problems associated with the corporate operations of the U.S. Mint is the constant battle in ensuring an adequate supply of metal alloys for coin production, and that these metal alloys avoid the potential melting point. Nickel has proven to be consistent in terms of value and has remained in current proportion sizes since the late 1800's (Perkins, 1992).  To solve some of the melting problems, we can look at what could be done in reducing the current rate of extraction from mines by possibly using more recycled copper, and the same with recycled nickel. When copper becomes oxidized some of the original metal can be lost. This is true with a fair amount of copper, but there is still a turnover rate of copper that has not been fully oxidized that can be utilized by the government in producing coins.

The pollution caused by mining is another problem associated with coins but the fact remains that they prove invaluable to economies worldwide. A great deal of the metal from the coins can be reused, though it will have to be supplemented by mining. There will always be a need to prevent counterfeiters and profiteers from taking advantage of the money system, and as this problem persists, it will be important for the government to take as much preventive action as possible. In the future the government and mining companies may come up innovative technologies to reduce the impact that mining has on the environment.

**Australian Polymer Currency**

Coins and paper currency remained the standard form of currency in Australia until the 1960s, when the threat of counterfeiting encouraged the Royal Australian Mint to develop a new form of currency. They began to develop a type of printable polymer (plastic) to be used in the place of paper. The first bill to utilize this technology was a limited edition ten-dollar banknote released in 1988 commemorating the bicentenary of the first settlement (RBA, 2010). Throughout the 1990s Australia continued to release new denominations in polymer notes until they had a complete set by 1996. This included denominations of 5,10, 20, 50, and 100 dollar polymer notes. Due to the significantly short life of small denominations such as one and two dollar bills, Australia had previously replaced these banknotes with coins (RBA, 2010). Since the first introduction of polymer bills in 1988, Australia has had many years to study the benefits and problems associated with plastic currency.

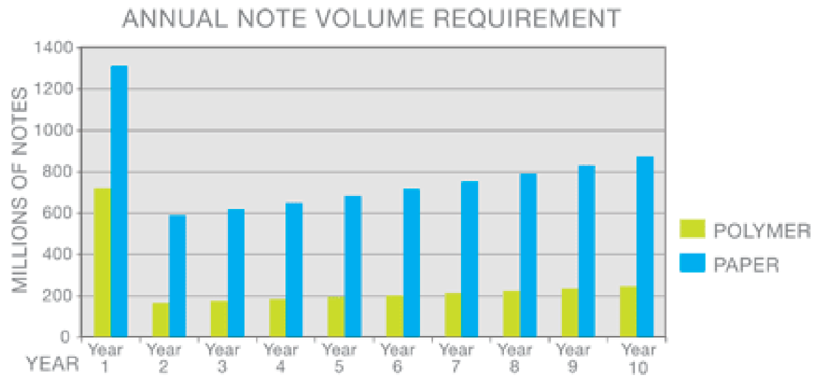
**Note Production**

Rather than using paper for their currency like the U.S., the Common Wealth of Australia makes its currency with polypropylene. This substance is prepared by polymerizing propylene, a gaseous byproduct of petroleum refining, in the presence of a catalyst under carefully controlled pressure and heat (Calafut, Maier 1998). Propylene is an unsaturated hydrocarbon containing only carbon and hydrogen atoms (C3H6). In the polymerization reaction, many propylene molecules (monomers) are joined together to form one large molecule of polypropylene (Calafut, Maier 1998). This material is very durable, having a high strength to weight ratio in addition to being one of the lightest thermoplastics at (.9g/cc). For this reason the plastic can withstand more than one million repeated folds while maintaining its original shape (Calafut, Maier 1998). The manufacturing process of the polypropylene is done through a process known as the "bubble process", which produces a film known as Biaxially Oriented Polypropylene (Boaden, A.). This process produces the trademark polymer known as Guardian® Polymer substrate by Securency International, which is a joint venture by the Reserve Bank of Australia and the private plastics company Innovia Films (Securency, 2010).

Due to the sensitive nature of this proprietary information only a limited amount of information is available regarding the manufacturing process. Printing plates, polymer substrate and ink come together in a vast printing hall, some 80 meters long, 40 meters wide and 10 meters high (Securency, 2010). This facility prints banknotes at speeds of up to 8,000 sheets per hour, sending them through four different printing machines to acquire each element of the bill. Due to the different size of banknotes you will get in between thirty-two and forty-five banknotes being printed on a single sheet (RBA, 2010).

**Benefits of Polymer**

The economic benefits have been quite tremendous since the introduction of polymer notes, as evidenced by the




thirty-three countries that import their notes from Australia. Polymer notes cost twice as much in production but last four times as long. As a result, fewer bills are printed annually, as shown in the table on the previous page. Fewer bills printed means that less money is spent in the long run. Australia found that within ten years of the introduction of polymer notes, the net benefit was around $90 million Australian, which translates into $65 million U.S. (Singh, N. 2008). The chart below compares the life expectancy of denominations of polymer to their corresponding paper bills:

| **Denomination** | **Paper** | **Plastic** |
|---|---|---|
| D1 | 6 months | 2 years |
| D2 | 1 year | 4 years |
| D3 | 2 years | 8 years |

| | | |
|---|---|---|
| D4 | 4 years | 16 years |
| D1=small denomination<br><br>D4=larger denomination | | |

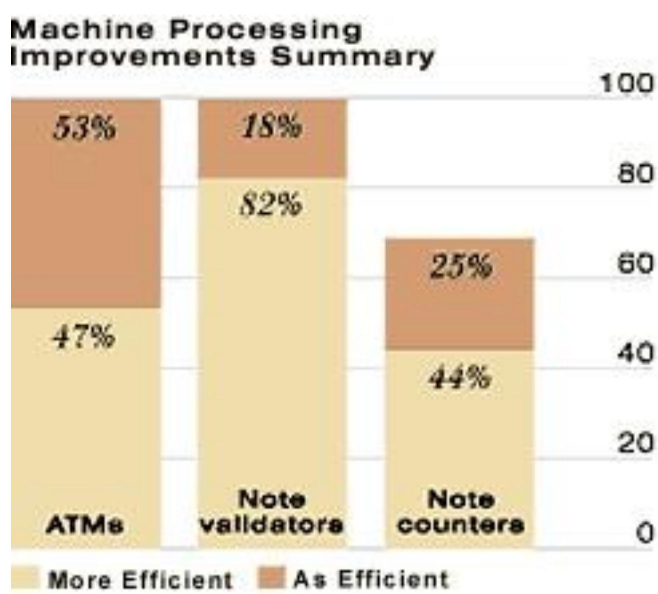
The extended banknote life is a huge benefit for countries issuing polymer notes. In New Zealand this was exemplified by a 42% reduction in notes unfit for circulation. While 57% of paper notes (40 million) were destroyed in 1997, only 15% of polymer notes (17 million) were deemed unfit for circulation (Singh, N. 2008). The benefits of a longer note life can be seen through the reduction in production cost as well. While paper notes were in circulation it cost $3.4 million per annum or 5.2 cents per note in circulation while polymer note expenses were only $2 million or 1.8 cents per note (Singh, N. 2008).

In addition to having a much longer life span, reducing material use, polymer notes can also be recycled. The base material of polymer notes, polypropylene, is from a non-renewable resource but, due to its recyclability, it has more than one life. Therefore, the manufacture of banknotes on polypropylene does not represent a final consumption of this resource (Securancy, 2010). Polymer banknotes (and the waste from production) are

granulated and recycled into useful plastic products such as compost bins, plumbing fittings and other household and industrial products such as the items above (Securency, 2010). The one issue that has come up with the recycling this product is that because of the long life of the notes there is a relatively low amount of bills that need to be destroyed, making it hard to find industries that will facilitate the implementation of this process (Boaden A.).

Another benefit of polymer technology that adds to its sustainability characteristics is its lack of permeability, as a result of its increased crystalynity. Thus molecules cannot easily diffuse through the crystalline matrix making the notes much cleaner than paper bank notes (Maier, Calafut 1998). Treated with various protective varnishes, it is non-porous and does not absorb water, oils, sweat, and most household chemicals. The protective coatings ensure that the bills are impervious to moisture and resist soiling (Securency, 2010).

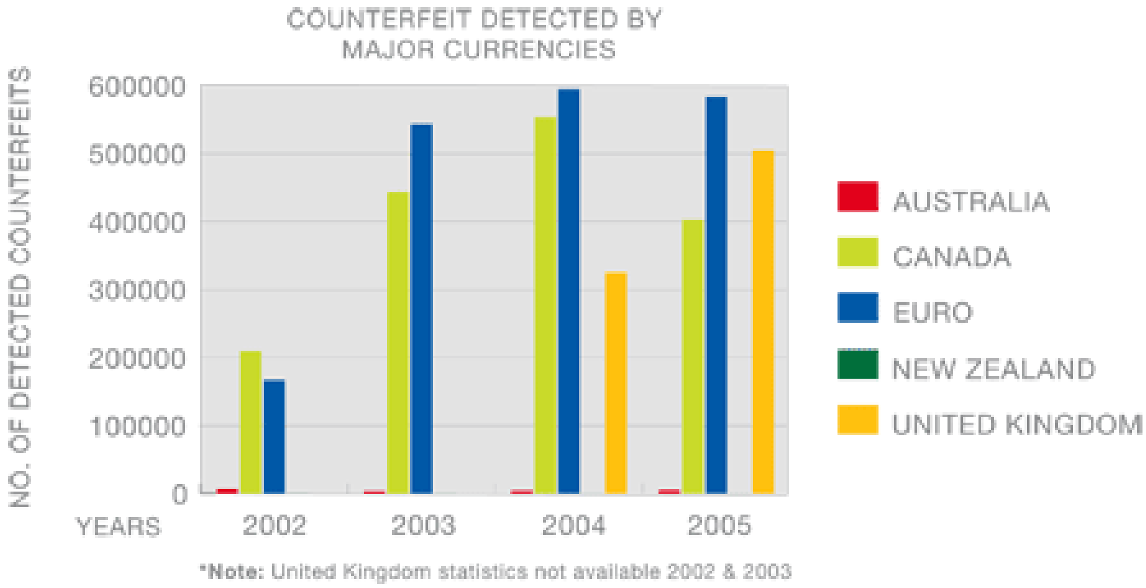
The cleanliness of notes translates into two major benefits. The first benefit is processing transactions are much more efficient. Being dust-free, far less maintenance is required for automatic teller machines, counting/sorting machines, etc, which results in higher processing rates and lower costs (Securency, 2010). There are now 38% fewer machines jams and 32% fewer service call-outs since the introduction of polymer notes (NPA, 2010). A study conducted by the



Asia Pacific Business Review compared polymer bills to paper bank notes and found that the polymer bills were more efficient or as efficient in regards to three different ways of counting notes, shown in chart above (Singh, N. 2008). The second benefit of the cleaner note is the effect on health. They are more hygienic and less susceptible to bacterial growth(Singh, N. 2008).

Finally, polymer bank notes provide two valuable social benefits: counterfeit deterrence and a means for visually impaired people to identify various denominations. Other than the superior durability, leading to a longer life of the bank note, the second greatest quality of these bank notes are their complex characteristics that have drastically reduced counterfeiting. The material used for bank notes is very costly to produce. The biaxially-oriented polypropylene (BOPP) manufacturing process to form the Guardian substrate differs quite a bit from other thermoplastics, making it very hard to replicate. It helps that the process is closely guarded and not available commercially. Secondly, polymer notes are able to use all past security features that were used in paper notes in addition to numerous other security features exclusive to polymer notes (Securency, 2010). One of the key security features is the transparent window where an optically variable device (OVD) is located (Singh, N. 2008). The bills have a core of clear film that is coated with polymer, but these windows are left uncoated (Coventry, 2001).

You cannot photocopy or scan a clear window, and toners do not contain white inks, which was a major issue with paper bank notes (Singh, N. 2008).




Additionally, less light is refracted reducing haze and increasing clarity, making the designs on polymer notes very crisp (Calafut, Maier 2008). The effect of polymer banknotes on counterfeiting deterrence can be seen in the bar graph on the previous page. Australia and New Zealand have virtually no counterfeits while countries with paper currency have a considerable amount.

As mentioned before, polymer bank notes can also assist the visually impaired. In Australia each banknote is a different length to distinguish between the various denominations. This differentiation is 7mm. Although this can be done with paper notes as well, polymer notes are better able to include raised print, which can also assist the blind. Blind Citizens Australia has developed a credit-card-sized device that uses the length differentials to help distinguish banknotes that they provide to all citizens in need (RBA, 2010).

Polymer banknotes have been around long enough to examine and improve upon their faults. They do have a few reported drawbacks, the most prominent drawback of which is that they are stiff and have an unnatural feel, which can lead to a bulky wallet (Singh, N. 2008). Other issues reported have to do with print durability, which was largely resolved after applying two coats of protective varnish.

**Final Thoughts**

The United States currency system is out of date and unsustainable, both socially and environmentally. We insist on continuing with our paper currency, despite the fact that new technology and progress has been made in the world of money. We are sentimental and favor the green paper bills and small change that has grown to be inconvenient. The United States is one of the few nations left that still hangs on to the one-cent coin.  Pennies are outdated and hold a great deal of copper and zinc that could be recycled and used for others coins. It is no surprise that many other countries, such as Canada and Australia, have done away with pennies completely. According to the Australian mint, the country ceased production of one and two cent coins in 1990 and 1989, respectively, and began to remove the coins from circulation in 1992 (AU Mint site).

Canada and Australia have also chosen to replace their smaller bills (one dollar and two dollar bills) with coinage. In 1987, Canada replaced their nickel composite dollar coin with a distinctive yellow aureate-nickel blended dollar coin. Decorated with a loon, the coin quickly picked up the affectionate nickname the “Looney”, while its two-dollar counterpart became the “Twooney” (McInnis, 2010, RCM, 2010). While it may cost the same or a little bit more to produce a coin as to produce a bill, the coins have a much longer life span. The average lifespan for a dollar bill is eighteen months, but a coin can last for up to thirty or even forty years according to some sources (Claus, Shepherd, and Wayne).

Australia has replaced its paper bills with polymer, and Canada plans to follow suit by 2010. While the U.S. Bureau of Printing and Engraving has executed measures to improve note production, it is not enough. Not only is a system of dollar coin and polymer bills more environmentally friendly, but it also resolves social issues. Coins of different weights and sizes are more easily distinguishable than our paper bills that are all the same size and texture. Tests done by the U.S. mint has shown that the Sacagawea dollar coin can be picked out by touch by the blind and visually impaired (Wu, 2000). Polymer bills in varying lengths and textures retain these textural differences better than their paper counterparts, which wear out quickly. These polymer bills would replace denominations higher than $1 and $2. If the decision that the U.S. treasury department is discriminating against the blind and visually impaired continues to be upheld, the entire currency system will have to be made over anyway. It would be in the best interest of the U.S. to keep up with technology (though at this point we are decades behind) and go for the more sustainable alternative. The bills are made from a non renewable resource, but it is a pre-existing byproduct and the length of the note life negates this. Australia, Romania, and New Zealand have all switched to polymer notes, with at least eighteen other countries introducing at least one polymer bill to the system. While it would be a very expensive endeavor, it would prove profitable in the long run. The

Australian Royal Treasury originally switched to polymer notes to deal with the issue of forgery, but has since made an enormous profit.

The Sacagawea golden dollar was introduced in 2000 to replace the unsuccessful Susan B. Anthony dollar and may prove to be a suitable replacement for the short-lived $1 bill. Though coins are twice as expensive to produce than dollar bills, costing 8 cents per dollar coin and 4 cents per paper bill, the life of a coin far surpasses that of a bill. A dollar coin can last anywhere from twenty to forty years, while the average life span for a dollar bill is eighteen months. In their lifecycle assessment of dollar coins and dollar bills, Claus, Shepherd and Wayne estimated that the production of both have roughly the same amount of waste. The difference is that metal waste from coin production can easily be melted back down and used to make new coins, while the paper pulp and ink waste must be heavily treated.

This switch to coins in place of smaller bills and polymer notes in the place of paper would mean that new plates would have to be drawn up. ATMs, vending machines, and cash boxes would have to be retrofitted to identify and accept the new currency. Staff would have to be trained on how to handle the new coins and bills as well, and education would have to be provided to the public to ensure the successful acceptance of the new currency. However, most of these costs would be one-time expenses that would prove profitable in the long run. In Australia processing and distribution requires fewer people than it did previously. With a staff of forty-one instead of 650, resources originally going into money production can now be allocated elsewhere. It has allowed for centralized production, with all polymer currency coming out of the National Note Processing Centre and coins coming out of the Australian Royal Mint (Coventry, 2001). In the U.S., we have four mints, in San Francisco, Denver, West Point, and Philadelphia, and two locations for the BEP in DC and Texas.

It would also have the added benefit of deterring counterfeiters. It seems that every time the U.S. treasury releases a new bill, it takes a matter of hours before the first counterfeits are on the market. Polymer bills are difficult, costly, and time consuming to produce. On top of the social and economic benefits, we would be doing something better for the environment and for our health. The bills are better quality and less wasteful, with less ink and dirt transfer, as well as less dust produced. The stiffer and more durable notes not only last longer, but they feed into machines and count better than paper bills. They also are cleaner, as the plastic does not absorb dirt and oils like paper does. This not only pleases the public, but professional cash handlers as well, who do not have to worry about where the bills they are touching have been (Coventry, 2001).

Switching to polymer currency would mean that, in the beginning at least, the U.S. would be dependent upon Australia for the polymer technology. Historically the U.S. has not been keen on relying on other countries for things, especially those as essential as currency. However, many countries already rely on Australia for their banknotes. Developing our own polymer process would be extremely expensive and time consuming, considering that AU's currency has been more than forty years in the making. However, the benefits far outweigh the costs. A currency system based on dollar coins and higher-denomination polymer bills would be environmentally sound and socially responsible.

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